THE SEPTEMBER SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

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RECENT BOOKS OF SCIENTIFIC INTEREST

History of the Sheffield Scientific School of Yale University, 1846–1922. RUSSELL H. CHITTENDEN. Two volumes. 610 pp. $10.00. New Haven, 1928.

The author was director of the Sheffield Scientific School from 1898 to 1922, and professor of physiological chemistry from 1882 to 1922. His account of the founding and development of Yale's Scientific School is an important contribution to the history of American education.

René Théophile Hyacinthe Laënnec. A Memoir by GERALD B. WEBB. 146 pp. 13 plates. $2.00. New York, 1928.

This biography of Laënnec is reprinted, with additions, from "Annals of Medical History," volume nine. Heretofore there has been no attempt to give a complete picture in the English language of this French physician, the inventor of the stethoscope.

The Fundamentals of Human Motivation. LEONARD T. TROLAND. xiv, 521 pp. $5.00. New York, 1928.

This book is intended to be a systematic treatment of human motivation. It attempts to answer certain questions which are of the utmost practical importance in human life, but which have not been adequately treated in available psychological texts.

Laboratory Manual of Physiological Chemistry. MEYER BODANSKY and MARION S. FAY. 234 pp. $2.00. New York, 1928.

This manual has been written at the suggestion of a number of teachers of biochemistry who needed a laboratory guide of this type. The authors recognize the growing tendency in favor of less qualitative and more quantitative work. Many experiments are included.

Fundamentals of Biology. ARTHUR W. HAUPT. xii, 358 pp. 256 figures. $3.00. New York, 1928.

A survey text on biology, emphasizing the fundamental principles common to all living things—teaching biology from the cultural viewpoint—showing the place and function of biology in modern thought.

Physics in Industry. Lectures delivered before the Institute of Physics. Volume V. 54 pp. Illustrated. London, 1927.

This volume contains lectures number X and XI: "The relationship of Physics to aeronautical science," by H. E. Wimperis, director of scientific research, air ministry, and "Physics in navigation," by F. E. Smith, director of scientific research, admiralty.

Folklore of the Teeth. LEO KAUNER. xiii, 316 pp. 17 illustrations. $4.00. New York, 1928.

The author attempts in this volume to give an outline of the folklore of the teeth, introducing it at the same time as a new branch of dental science, just as the folklore of medicine is, or should by all means be, considered as a branch of medical science.

Ernest Harold Baynes. Naturalist and Crusader. RAYMOND GORGES. xii, 255 pp. Illustrated. $4.00. Boston, 1928.

This is the life-story of an unusual man, a man who loved animals and made them love him, and who wrote accounts of his experiences that were no less true than fascinating.

Radio. A Study of First Principles. For Schools, Evening Classes and Home Study. ELENER E. BURNS. xv, 255 pp. 211 figures. $2.00. New York, 1928.

This book is an attempt to present, simply and clearly, the fundamental principles of electricity applied in radio. It consists principally of material which the author has used for some years in teaching boys of sixteen to eighteen years of age.

Elements of Botany. RICHARD M. HOLMAN and WILFRED W. ROBBINS. 380 pp. 241 figures. $2.75. New York, 1928.

This text embodies the same material and viewpoint as that of the "Textbook of General Botany," published by these authors in 1924, but so abridged as to fit it especially for use in institutions where the subject is not extensively studied.

Organic Chemistry: A Brief Introductory Course. JAMES B. CONANT. 291 pp. $2.60. New York, 1928.

A text-book for the first course of a year's length or, with omissions, a one-semester course. Emphasis is placed on subjects having either scientific or industrial importance.

Life in the Stars. SIR FRANCIS YOUNGHUSBAND. xiv, 222 pp. Illustrated. $3.75. New York, 1928.

"Life in the Stars" is a study of the heavenly bodies not as seen through a telescope nor through the temperament of a poet, but as seen outdoors face to face by a man with the mind of a student and the heart of a mystic.

What am I? EDWARD GLEASON SPAULDING. ix, 273 pp. $2.00. New York, 1928.

In this book the author endeavors to discuss in popular form certain problems vital to anyone who reflects about himself, the nature of knowledge, fundamental questions of conduct and religious belief.

The Ways of Behaviorism. JOHN B. WATSON. 152 pp. $2.00. New York, 1928.

The author explains this new science in terms that everyone can understand. A study is made of the methods to be employed in discovering why people act as they do and how they can be influenced effectively.

The books noted above may be obtained at the publishers' regular rates from
THE SCIENCE PRESS DISTRIBUTING COMPANY, Grand Central Terminal, N. Y. (*See page ix.*)

THE SCIENTIFIC MONTHLY

SEPTEMBER, 1928

INSECTS: THE PEOPLE AND THE STATE

By Dr. H. T. FERNALD

AMHERST, MASS.

THROUGH all the ages two views as to the importance of insects in their relation to man have been in existence. The one may be illustrated by the statement of an old farmer who claimed that there were no insect injuries to crops when he was a boy: the other, a record of protests, in one form or another, when unusual outbreaks made destruction evident.

Probably the first view was always the result of lack of observation or apathy. It called for no action on the part of those concerned; no knowledge of what to do when treatment was needed was available; in some cases even a sort of fatalism was present, such as that expressed by the farmer who pulled out the white daisies from his fields for ten successive years and then gave up the task, stating that he believed it was foreordained that the daisies should grow on his land and that he would no longer oppose God's will.

The other view of insect importance has long been held, though often with no hope of relief. More than two thousand years ago the Mournful Prophet feelingly said: "That which the Palmerworm hath left, has the locust eaten; and that which the locust hath left, has the cankerworm eaten; and that which the cankerworm hath left, has the caterpillar eaten."

Unusual outbreaks of insects and material damage resulting have always led to the desire to do something—anything—to prevent or check the ravages of these pests, and this has manifested itself in at least two ways: the one, that of appealing for aid; the other, active, militant opposition.

The former method is well illustrated by the following clipping from a newspaper:

> July 28, 1925.—Farmers in the parish of Big Point are praying to God for the extermination of the corn borer, the destructive grub which has multiplied to an alarming extent and which threatens to totally destroy the corn crop.
>
> Sunday afternoon more than 400 people, the majority farmers and their sons, followed Rev. Father Joseph Emery around the parish. At the four corners of the parish the procession was halted while the priest offered prayers. They returned to the church where a special service of prayer was held.

Examples of the more militant way are also not unusual, though more frequent in former years. Most often the method followed was to legally cite the insects to appear before a judge in court, for trial. Here, both sides were presented by legal counsel and a verdict was given. This was "guilty" in at least nearly every case, followed by a sentence that the insects be excommunicated, and their disappearance later was considered as evidence that the sentence had been carried out.

In this country, during the early colonial and federal periods, the problem of producing a food supply sufficient to feed the people hardly existed,

but unusual losses to crops by the ravages of insects gradually turned the attention of those concerned to the situation.

The nineteenth century, however, was a period which witnessed rapid development in the United States. The colonies which had become an infant republic now became a nation. The middle west was gradually settled by emigrants from the east, and cultivation of the land increased at a wonderful pace. The introduction of the steam engine and its adaptation to ocean travel reduced the time required to cross the Atlantic from nearly a month to about twelve or fourteen days. New settlements sprang up almost over night and manufacturing began to draw its workers away from the farms, thus demanding a greater production of crops with which to feed those not occupied in raising them.

During this period, then, began the action of changes which have ever since made the subject of insect ravages of increasing importance; changes so familiar that they hardly need more than mention here.

The increasing value of food crops called for a greater acreage of them, and this meant a greater food supply for the insects attacking those crops: if an insect had ever doubted whether food sufficient for her young to reach maturity could be found, that doubt would now be dispelled for several generations at least, as she viewed the broad acres, now springing up on all sides, of the favorite food plant of her species. If European pests, hampered at home by the restraint of parasites and other enemies, had hesitated to cross the ocean for fear of death during the long voyage, the reduction of the time necessary to only two weeks would be a sufficient encouragement to attempt the crossing in the hope of obtaining escape from the fetters of their enemies in the "land of the free." After all, simply grant the possession of intelligence to insects and how similar would be the aims of both the early human and insect emigrants to this country. Favored too, at this time, by the beginning of imports of plants and other materials from Europe, there is little to wonder at if many of these brought to the United States with them insects which, escaping from their enemies in this way, could rapidly reach destructive abundance, thus adding their injuries to those of the pests native to this country.

During this period, however, the only interest shown in insects by the government appears to have been that, in connection with exploring expeditions to the unknown west, collections were made and sent to various entomologists for examination. A number of papers, valuable from the systematic standpoint, resulted, and the practice of gathering specimens in this way was continued as long as such exploring expeditions were sent out. The economic bearings of entomology, though, were not recognized. Such crop losses as occurred were either ignored or felt only locally by those most concerned. That insect pests were coming into this country was either unknown or also ignored.

Agriculture, even in its broadest phases, was practically untouched by the government and little recognition of its importance to the welfare of the nation seems to have entered the official mind, despite President Washington's ably presented arguments, until about 1839, when a small appropriation for collecting and distributing seeds, prosecuting agricultural investigations and procuring agricultural statistics was made and placed in the hands of the commissioner of patents.

Thereafter, miscellaneous articles on different phases of agriculture, and statistics on the subject, were printed in the Patent Office annual reports, the work seeming to have been organized somewhat on the basis of a division.

It seems to have been about at this

time that the idea developed that insects' injuries might, in part at least, be prevented or reduced; and by 1854 over a dozen foreign insects had reached this country, their work was beginning to be felt, and the public demand for aid on insect problems had become so strong that a "special agent, for collecting statistics and other information on seeds, fruits and insects in the United States," was commissioned June 14, 1854.

The special agent appointed was Townend Glover, born in Brazil, but of an English family, who had come to the United States in 1836 and, at the time of his appointment, was forty-one years of age. From a child he had been a lover of nature, a born collector, with strong artistic inclinations, which he developed by study in Europe, and his favorite subjects to paint were plants and animals.

In this country he settled in New York state, but was an extensive traveler, particularly in the south. Becoming interested in pomology he utilized his artist's instincts by making models of fruits and produced an extensive collection of about two thousand models. It was these, probably, which attracted the attention of the federal authorities to Glover and led to his appointment as a "special agent," and during his first years, at least, in this position, his duties were far from being purely entomological.

One season was spent largely in Florida and resulted, among other things, in the production of the following lines:

From red-bugs and bed-bugs, from sand-flies
and land-flies,
Mosquitoes, gallinippers and fleas,
From hog-ticks and dog-ticks, from hen-lice
and men-lice
We pray thee, good Lord, give us ease.

The place in which Glover was obliged to work was evidently unpleasant. The entire agricultural work of the government at that time was carried on in a single basement room in the Patent Office. There Glover, his collection of models and all the material for his study sought for space in which to live, and found it not. Too cramped quarters and a satisfactory product never go together.

His official relations also, during this period, were evidently far from pleasant. Only four articles on insects by him appear in the reports from 1854 to 1858, inclusive, and early in 1859 he gave up his position, but only for more active work, teaching, writing and collecting.

During the succeeding years outside entomologists were occasionally induced to prepare articles on insects for the annual reports, but no further attempt to fill the position he left was made.

In 1862 the agricultural work was reorganized by the establishment of a department of agriculture, and the following spring Glover was appointed United States entomologist to the new department, returning to his basement room. Shortly afterward another room was found for the museum and a secretary was obtained, chiefly for clerical work.

Correspondence increased; annual reports became a burden; the museum was growing and, after a few years, an assistant—not trained in entomology, however—was employed.

In 1868, when the department moved into its new building, Glover for the first time was able to have a room in which he could keep his library and be less interrupted in his work, and here he continued until 1878, when failing health obliged him to retire.

During this period he issued seventeen reports, covering a large part of the ground of economic entomology, though doing little or nothing in the way of field observation or experiment. He apparently considered his previous travels had given him sufficient knowledge of field conditions, and experi-

mental work of any kind on insects was then unknown. Indeed, it was eight years after his appointment before the idea of combating insects by stomach poisons was developed.

Glover's work was done under conditions far from encouraging. Obliged to cover much more than entomology; with at most only one or two assistants who had no entomological training; and with his thoughts, much of the time, turned to the building up of an agricultural museum, it is not strange that his departmental work on insects is to-day of little value. His outside time was devoted to entomology, it is true, but these writings, etched on copper by hand and issued in editions of fifty copies only, were practically unobtainable. His collections? He had none. He considered the picture of an insect of much more importance than the specimen itself.

Between 1873 and 1876 much of the territory west of the Mississippi River was devastated by migrations of the Rocky Mountain locust. The complete destruction of the crops of settlers in this region and the sufferings entailed thereby created a very general feeling that steps should be taken by Congress to relieve the situation. In response, an act was passed in 1877 creating a commission to study the subject and find some method of mitigating these conditions. The government entomologist was not called upon for this purpose, but three men—Riley, then state entomologist of Missouri; Packard, well known for his studies on insects in the east, and Thomas, the state entomologist of Illinois—were selected, and the commission was at first placed under the U. S. Geological and Geographical Survey of the Territories, in the Department of the Interior, though later transferred to the Department of Agriculture. The results of this study were included in seven bulletins and five reports which, in addition to the Rocky Mountain locust, included work on cotton insects, shade-tree insects and forest insects as well. Valuable as these are, how they ever could have been published as the legitimate work of the commission is even yet not comprehended.

During Glover's later years in office, entomology began to receive more attention, and New York, Illinois and Missouri each established the position of state entomologist. It was only natural, then, that on Glover's retirement one of these should be chosen as his successor, and C. V. Riley, of Missouri, was selected.

Riley's seven Missouri reports mark the practical beginning of applied control methods. Going to Washington he brought this idea with him, and also an assistant, Theodore Pergande. In November of that year, two other assistants were added, E. A. Schwarz and L. O. Howard. Here, for the first time, we have entomologically trained assistants to work with the entomologist.

Riley had but little opportunity to develop his work, however, for in less than a year, as the result of disagreements with the commissioner, he resigned and was followed, in 1879, by Professor J. H. Comstock, of Cornell University, who, the preceding year, had been investigating cotton insects as a temporary field agent for Riley.

Comstock brought to the work the keenly analytical mind of a trained scientist. Surveying the field as it opened before him, with inquiries and pleas for aid from all parts of the country, he saw that in the scale insects there was a long list of important pests which had never been carefully studied. At first the completion of his previous investigations on cotton pests consumed his time, but during his second year he began a thoroughly scientific study of the scales and at the same time arranged that Howard, who had become his first assistant, should study thir parasites.

At this time the entomological work

was done in three rooms on the second story at the west end of the old Agricultural Building. Ascending the stairs at that end, one directly faced a door into a small room. The door was generally open, affording a fine opportunity for a study of the back of the entomologist himself bending over a microscope and often so absorbed in his work that a prolonged examination of the room and its occupant failed to produce any attention. Of the two rooms on the west end itself the first was occupied chiefly by a collection of insects which had been exhibited at the then recent Centennial Exposition at Philadelphia. In the other room the department artist, Mr. Marx, might generally be found preparing drawings of scale insects, tracing them with unerring hand on the wood blocks. Further back a young man was poring over a microscope or trying to induce some tiny scale parasite to spread its wings and legs into a position where they could be seen more clearly, by pressing or sliding the cover slip over the mount in one direction or another. At another table the wife of the entomologist was busily engaged in making drawings of insects or attending to some of the many duties of the office, while Pergande was occupied in raising insects and noting their early stages. Work, steady and hard work was the motto, as long as the light should last, at least during the short winter days of 1879—80, a winter I myself spent in Washington.

How well I remember those days. One day I saw Mr. Marx carefully drawing a tuft of pine needles with scale insects on them. Even now, after forty-seven years, I sometimes take up the report of the entomologist for 1880 and turn to Plate VI and seem to see again the artist at his work. Sometimes during the dark December afternoons the light became so poor that a little relief for the sake of tired eyes became necessary, and I remember hearing once, at such a time, the following conversation, "Mr. Marx, are you married?" "Yes." "Well, have you any family?" "Noo—but I have some shpiders," which reminds us that, though an artist by profession, he was also one of the leading arachnologists of this country.

With a change of administration, at the end of rather less than two years, Comstock retired, returning to his duties at Cornell, and Riley, in the spring of 1881, again became government entomologist, continuing in this position until June, 1894.

Upon Riley's resumption of this position his assistants became Howard, Schwarz, Pergande and B. Pickman Mann. Shortly after this time a reorganization established this branch as a division, giving it a more definite standing, which was no more than its due, as its work was now everywhere becoming appreciated. People from many parts of the country were beginning to ask for aid in the solution of their insect problems, either directly or through their congressmen, and it became both necessary and possible, with increased appropriations, to obtain more assistants. By 1888 we find, in addition to the entomologist himself, six office assistants, and eight field agents working more or less of the time, and in 1889 C. L. Marlatt joined the division. At the time of Riley's retirement a total of nine workers in the division is recorded, though the appropriations during this period rarely if ever exceeded $30,000 a year, and toward the end of each year money was frequently an almost undiscoverable article in the division, either for work or in the pockets of the members of the staff.

The most striking developments of Riley's period were: the establishment of work in bee culture and sericulture (this last discontinued later); a study of the insect food of birds, leading, after a time, to the foundation of what is now the Bureau of Biological Survey;

the discovery by Hubbard of true kerosene emulsion; the development of the cyclone or Riley nozzle, the precursor of most of our modern spray nozzles; the appointment of temporary field agents; the introduction of the vedalia into California to prey upon the fluted scale—the first attempt to utilize and increase one of nature's own control methods—and the beginning of the use of hydrocyanic acid gas as a fumigant.

Riley was a hard worker—even a hard driver—sometimes difficult to get along with; at others a delightful companion. He had a way of cutting departmental red tape which was often extremely irritating to his superior officers and which was continually getting him into trouble. Conscious of his ability, which he by no means underrated, he often seemed arrogant and impatient with others, but was always quite susceptible to flattery.

With Riley's retirement in 1894, his mantle fell upon Howard, his first assistant, who had already given fifteen years of service in the division and who now became its fourth head. During the thirty-three years which followed, he has carried on the duties of this position and laid them down only last October. But what a change has taken place during those thirty-three years! To describe the development of the work adequately during this period is wholly impossible in the time available, and only a few of its main features can be touched upon.

By the last decade of the nineteenth century this country could truly be described as wealthy. Luxuries of every kind were being brought in from all parts of the world. Rare plants, great and small, were added to those already found here, and a large importing business in these lines became established. Foreign nurseries, which were able to grow horticultural materials cheaper than we could, began shipping to the United States enormous amounts of their productions, and such material could now quickly reach this country. Little wonder was it that various insect pests from other lands could—and did—frequently appear in different parts of the United States; in fact, between 1885 and 1905 fully half a dozen insects of serious importance reached this country, some in the east, some in the south, some in the west.

Much of the work of the division of entomology during this period was, of necessity, a study of these pests, about which little or nothing was known. With the gypsy and brown-tail moths in New England, the cotton boll weevil in the south, and the San Jose scale almost everywhere, active investigation in different parts of the country became absolutely necessary, and this led to the first establishment of field stations, at points which promised the best opportunities for results, and to an increase in the number of trained workers.

The success of introducing the lady beetle enemy of the fluted scale into California—by this time repeated successfully in other countries—was most suggestive for making similar attempts with the enemies of these newly acquired residents. Accordingly, organized efforts to obtain and bring in enemies of the gypsy and brown-tail moths and of various scale insects were begun, inaugurating a new line of government work, to which the fluted scale work had been merely a preface. Cooperation with entomologists of other countries in this led to efforts to aid *them* in a similar way, resulting in the development of a large business in importing and exporting such insects as promised to be of value in the work.

Fig growing in the west had been attempted for years, but the qualities of the Smyrna fig had never been successfully obtained. One of the early problems of the division was a study of this situation, which finally led to the intro-

duction into California of the Blastophaga fig insect, which plays such an important part in caprification of the fig, and the resultant production of this fruit having a flavor equal to or even finer than the imported Smyrna figs and with a higher sugar content. Thus by the introduction and establishment of the Blastophaga, the fig trees are enabled to produce seeds, the cause of the peculiarly rich flavor of this variety of fig and permit the development of this industry in the United States.

The work of the division, under these conditions, rapidly increased. Appropriations of less than $17,000 in 1895, for actual work and with some salaries paid out of this inadequate amount, became evidently too small, and Congress, recognizing the necessity, began giving larger sums.

This growth was also marked in the other sections of the department. Agricultural demands in all lines were becoming greater, and the original building became entirely inadequate to house the activities of the department. Relief became necessary, and rented quarters were obtained in some cases, while, in part for the division of entomology, a new building was erected just southeast of the old one. This was occupied by the division in the autumn of 1895 and greatly facilitated the work.

In the early part of Dr. Howard's term there arose the problem of the insect collections which were accumulating. Housed in a crowded and nonfireproof building, the division could find neither a safe place nor room for them there. The Riley collection was already in the fireproof National Museum, where a national collection of insects would naturally be expected to be found, and in view of all these facts an arrangement was made whereby the departmental material should thereafter be concentrated in the National Museum under the supervision of Dr. Howard as honorary curator, and cared for partly by workers from the division, partly by museum workers. In this way the formation of two distinct collections, situated in different places in the same city, was avoided and the whole problem simplified. That this plan was a wise one there can be no question, and it has resulted in forming the largest collection in the United States.

This has also provided an outlet, through the publications of the museum and of the Smithsonian Institution, for the appearance of many valuable taxonomic papers which would hardly have seen the light otherwise, and left the bulletins and other publications of the division available for more economic articles, life histories, control methods and other phases of the subject.

The accomplishments just named fall far short of indicating the activities of the division between 1885 and 1910, however. Many of the older problems left from earlier days remained. Outbreaks of different insects, from time to time, required special attention; life history studies; bibliographic work, continuing that begun earlier; an increasing correspondence, and the testing of insecticides were prosecuted in addition, even more actively than before.

Just before the beginning of the present century, the relation of insects to the health of man and domestic animals also began to be realized. This was probably due, in part at least, to the work of Sir Donald Ross on mosquitoes and malaria. Here was not only a new but also an important field for entomological research, and its probable value to the people in large areas of the United States made an immediate study of the subject desirable. Beginning with studies on the life history of mosquitoes, this line of investigation has been developed more and more as the years have gone by, and other insects as possible vectors of disease have enlarged its

scope. The significance of the house fly as a vector of typhoid fever and perhaps other diseases, revealed so strikingly during the Spanish War, mosquitoes in their relations to yellow fever and many other similar insect and disease relations have now become familiar. Proof of the method of transfer of yellow fever from one person to another has become one of the most widely known instances of human self-sacrifice in the interests of science, and that this was carried out by army medical officers but shows that more than one department of the government has taken up problems in which insects are involved, for the benefit of the people.

All this time the same factors which had begun to operate nearly a century before were becoming increasingly active. More rapid transportation and the ever-growing bulk of imports from Europe, and the beginning of this now from the South and the Orient, were multiplying the opportunities for insects to reach this country, and many came. Immense tracts planted to a single crop made easy the development of various species to devastating abundance, and calls for aid in all directions became almost overwhelming. A systematized classification of the different lines undertaken, and to be undertaken, became necessary, and the division, as thus reorganized, was made a bureau on July 1, 1904. Since then a number of increases of branches or divisions have been made.

The entomologist at present is expected to be not only an entomologist but an arthropodist as well. For years pleas for aid in controlling the Texas fever tick, such a serious pest of cattle in the south, had been coming to the bureau. Taking up this subject the life of the tick was carefully studied and, in cooperation with the Bureau of Animal Industry, quarantine methods and treatments were devised for the suppression of this pest. The Bureau of Animal Industry, on taking up this regulatory work in 1906, found the tick was present in 985 counties of fifteen different states. Persistently it has moved to free one county after another until, at the present time, 760 counties and eight states have been released from quarantine. When we recall that ticks so affect the vitality of cattle, when present in abundance, as to greatly reduce the amount of milk produced and cause the cattle to become thin, weak and often die, the importance of this work to the whole south becomes evident.

Another tick, apparently not dangerous to animals but almost certainly fatal to man in some parts of the West, is the Rocky Mountain spotted fever tick. This pest too has been studied by the Bureau of Entomology and also by the U. S. Public Health Service, and a recent result has been the production of a vaccine which gives protection against the fever.

Study of insecticides on the market has shown that many were sold either with absurd claims for their effectiveness, were of no value, or were so compounded as to be dangerous to use. This led to the passage by Congress, in 1910, of the federal insecticide and fungicide act, which is to prevent the manufacture, transportation and sale of adulterated or misbranded insecticides and fungicides. To carry out this act, the Insecticide and Fungicide Board was formed, and under its supervision insecticides, fungicides and disinfectants are tested for their composition, claims made for efficiency and their action on plants. This work is done in part in the Bureau of Chemistry, where the substances are analyzed, and in part by the Bureau of Entomology at a field station where the insecticides are tested both for their effectiveness against insects and their effect on the plants involved.

In the Bureau of Chemistry this regulatory work is supplemented by research as well, both in discovering new insecticides and in finding better and less expensive ways of making the present ones. Here the recent insecticide, calcium arsenate, was largely developed, and the discovery that the insecticidal factor of pyrethrum could be extracted by the use of a mineral oil of about the distillation point of kerosene was made.

The arrival of serious pests in different parts of the country had before this time shown that entomological investigations could not always be successfully conducted at Washington but should be carried on where the insects were already present. The establishment of the field stations in Massachusetts for the study of the gypsy and brown-tail moths and in Texas for work on the boll weevil had plainly revealed their advantages. The same situation was also evident for other pests, longer in this country, which had shown variations in life or habits in different sections. The codling moth, for example, seems to lead a different life in the Hood River region of Oregon from what it does in the Ozark Mountains of Arkansas or in the hills of New England. To properly advise when and how to use control measures to the best advantage, a knowledge of local conditions is needed, and this can be obtained only by local studies. The control of the Hessian fly in Pennsylvania may be quite different from that needed in California; the bark beetles of North Carolina are not the same as those of Idaho, yet may be equally serious and need equal study.

Realization of the truth of these facts and the gratifying results obtained by the field stations first established gradually led to the formation of others, not always permanently located, but moving from time to time in accordance with any need for a change. The appearance, in 1904, of the alfalfa weevil in Utah and its spread to adjoining states has been met by local field stations for studies and control experiments. The large stock-raising districts have been areas in which to take up the insect pests of cattle, and the spread of the European corn borer has resulted in the formation of field stations in Massachusetts, New York, Ohio and Michigan.

These stations are also of use as centers from which enemies of these insects, introduced from foreign countries, can advantageously be liberated in places where their work is most likely to be an assured success, and many millions of these tiny helpers of man are thus introduced and distributed each year.

Gathering them in Europe, China, Japan, India, or wherever these enemies of our pests can best be obtained, is of itself no easy or simple problem, if any number are sent to this country. Even when once obtained there are almost innumerable difficulties in the way of getting them here in good condition, and when a shipment does thus arrive, the possibilities that some of their own enemies have come along with them can not be forgotten. Hence follows the rearing of these parasites in this country under such conditions that all their enemies, which may have accompanied them, shall be found and destroyed before they themselves are turned loose. This is work for trained experts in this line, but it is being done on a large scale and when "safety first" has finally been assured, these parasites and predators are set to work.

How great the work of importation of these foreign enemies of our present insect pests has become is not fully realized. This has been so divided among different sections of the bureau that no one seems to have thought of viewing the subject as a whole. The fullest data available, however, indicate that nearly 125 different species of parasites and predators have been successfully brought

to this country and, in many cases, hundreds of thousands of a kind liberated.

How successful they have all been in establishing themselves it is impossible to state. Over thirty are known to be actively at work destroying their old insect foods of foreign lands, here, and only time can show how many more are doing the same thing, unknown to us. Already, parasites not recovered for years after they were turned loose have at last been found hard at work, and a final verdict as to the successful establishment and efficiency of any such an insect can not safely be made for at least twenty-five years after its liberation.

Collecting the foreign enemies of our pests is most difficult without well-equipped stations at which to work and this has led, of late years, to the establishment of field stations abroad, which have already justified their existence.

As a result of the development of parasite importations and of insect studies and methods of control in the localities best adapted to such work, the number of temporary field stations has now increased to more than seventy, located in thirty-three different states, and six in other parts of the world.

Men capable of doing investigations of this kind have of course been needed, and this has led, year by year, to an increase of the staff workers and to the addition of temporary helpers during the periods when most active investigation and control experiments are being carried on. A corresponding increase in the clerical staff has also been necessary, and the roll of members of the bureau has greatly increased as new activities have been added.

But even now, more insect problems than ever before are awaiting solution. The discovery of the European corn borer in this country in 1917, first in Massachusetts, then in New York and later farther west, with its terrific menace to the welfare of our most valuable crop, has demanded that the most active and thorough measures possible be taken.

The discovery of the Japanese beetle in New Jersey in 1916 showed that another menace to our crops had reached this country, and its rapid spread and increase in abundance called for vigorous measures, not only in a study of the insect but also in quarantine work. Five stations in different places have this pest among their problems.

For this insect it has been found that though the beetle can be poisoned by lead arsenate, it is rather repelled by it, and here we have the first prominent development, at least, of the idea of using attrahents. Repellents have long been used to drive insects away, but poisoned baits appear to have been about the only place where something has been used to actually attract insects to any extent. With the Japanese beetle the idea of coating the poison with an attrahent, to induce the beetle to feed upon it, represents, in a degree, a new angle of attack upon our insect pests.

Everywhere improved control methods are also being sought, new remedies tested, and better ways in which to apply these substances. One of the latest forms of application has been that by airplane dusting, which has been tried in the forests of New England against the gypsy moth; in the central states against various insects, and in the south against cotton pests. The results of these trials have, in some cases, revealed most interesting and unsuspected facts with reference to choice of material to use, when to apply it and also the limitations of airplanes for this purpose.

As early as the year 1898 the fact that under existent conditions many foreign insects were arriving in this country on plants brought in was evident, and in his report for that year the entomologist made a plea for the pro-

tection of this country by an inspection of all materials imported which are liable to include dangerous pests. This was repeated with even greater force in the years which followed and resulted, in 1912, in the passage of an Act of Congress establishing a Federal Horticultural Board, which was given the power to establish both domestic and foreign quarantines. The former were to prevent insects prevalent in some parts of the country from passing to non-infested regions by means of shipments out of the infested districts. The foreign quarantines were for the examination of all imports into this country from abroad, which might contain pests not already here.

This established barrier lines and inspection stations with their staffs of inspectors whose duties were first, to find any pests which might be present in a shipment; and, second, to reject any shipment found infested or to so treat it as to destroy the insects. Plant diseases were also included in this work of the board.

The number of known or potential pests which have been discovered, as the result of this service, has been surprising. Menaced on the south by the fruit fly, the pink boll worm and others; on the east by the nun moth, processionary caterpillar and many other familiar European pests, and on the west by the little-known enemies of crops in the Orient, our ignorance of the insects of other countries was so evident at first that in many cases no one could say whether a particular insect found in a shipment was likely to be important if it should successfully establish itself in this country, though none of them was above suspicion in this regard.

As the result of fifteen years of work of the Federal Quarantine Board, we have to-day, protecting the borders of this country at about forty places, men inspecting imports and destroying the pests found. The states themselves are cooperating in this work and the board has this year 233 regular employees and an appropriation of over eight hundred thousand dollars. About forty of the quarantines issued are now in force, and in the case of domestic quarantines the limits of the quarantined areas are changed from time to time as the conditions with reference to the distribution of the pest change.

Though the Federal Horticultural Board is not a section of the Bureau of Entomology, the interests of the two are closely connected and, to a certain extent, interlock, while the board itself consists of members of the Bureaus of Entomology, Plant Industry and Forestry.

Such a growth as has here been sketched, in so far as the Bureau of Entomology is concerned, can perhaps be best shown by some comparisons.

When Riley retired there were nine workers in the section and a few field agents employed from time to time. On July 1, 1927, there were 530 permanent employees of the bureau, 136 in Washington and 394 in the field. Of these 530 people, 280 were carrying on professional and scientific work; eighty-seven were rated as giving subprofessional service; administrative, clerical and fiscal duties enrolled 115; twenty-four were field agents, and twenty-four more were doing janitor work of one form or another.

Drawing as close a comparison as possible between the conditions in 1894 and 1927, we find nine as compared with at least 280 scientific workers. Instead of thirty thousand dollars a year, or less, the appropriations for 1927–28 were three million, seventy-eight thousand, two hundred and sixty-five dollars, and a special appropriation for corn borer work, available during a year and a third, of ten million dollars more. By a different mode of expression, the per-

sonnel has increased since Dr. Howard became entomologist over fifty times, and the money appropriated, over one hundred times: the subjects of investigation have also multiplied, though how many times can hardly be determined.

One reason for this increase, which has not as yet been mentioned, is that modern study has shown us how little we really know of any insect. In 1896 a book on the gypsy moth was published, of which it was said that it was the most complete monograph of an insect which had ever been published. Yet, since that time, the researches of the bureau on that same insect have resulted in accumulating data to make at least two more books of the size of the first and have given much about the life of the insect which is of value as bearing on control.

New discoveries about old pests; new points in life history, habits and responses to climatic conditions: who can tell when some seemingly small discovery may not revolutionize our methods of control?

Further mention of the various lines of work which occupy the attention of the bureau would be but multiplying examples and wearying to those here to-night. Let us, rather, for a moment look at the work by the government for the people against insects as a whole.

First: Many of the very factors which have made this country a great nation have been those which would develop also a great insect population. Easy access to this country has led to an enormous immigration from abroad, both of people and of insects. Only recently have the laws against the unrestricted admission of human beings been enacted, and it is worthy of note that insect immigration was barred first. The police force—the regulatory service against foreign insects and plant diseases—was more alert than were the people, as to the nature and danger of bringing many types of foreign elements into the country. That the bars are now shut has not solved the problem: it has only narrowed it.

Second: Seventy-five years ago such a thing as economic entomology was almost unknown. We have been obliged to learn by experience what insect pests really mean to a country and then how to control them. Once begun, though, progress has been rapid.

Third: The development of entomological work by the federal government demonstrates what has just been stated. We see Glover, a good entomologist as entomologists were in those days, feeling his way along, a pioneer in a strange land, and much of the time obliged to attend to other matters. We see Comstock, the trained scientist, realizing that the true basis of successful control work must be based on a knowledge of just which insect is concerned in every case, learning to recognize them and studying their lives to discover the best places for attack. We see Riley carrying this idea still farther, seeking for new materials of warfare and new machinery to use in the war. We see the enemies' forces multiplying in numbers under our modern modes of life, and new hordes joining the enemy. And we see Howard for thirty-three years battling, at first almost alone, against the invaders and those already here; calling on all the sources of knowledge available; searching for the weak spots in the enemies' armor, and for better materials of warfare; and only recently well supported with men and money for the struggle. Attacked through our crops and with our health menaced in all parts of this broad land, the field to cover and save as much of as possible would have been too great for any one with a smaller vision, an intellect less keen and far-seeing, and a strength less great, even when the prospect of winning some particular battle

appeared to be small. There must have been some dark days, however—days when there was so much needing to be done and so little to do with. We all know these dark days, when our hopes and our plans seem destined to come to naught. Only great courage and resolution can carry one through at times.

How serious the relation between man and insects was, and is, is shown by the statement of one of the leading biologists of this country, made in the spring of 1887 to a public audience, in nearly these words:

> Man is far from being one of the most powerful of animals. The elephant, the lion, the tiger, and many others could kill him with a single blow. Yet man to-day, because of his brain power and will, dominates all creation and, so far as can now be seen, will continue to do so.
>
> The sole danger now in sight seems to be the possibility that hordes of tiny animals, themselves feeding on the plants which serve as the food of man, and with the power of increase from one to millions in a few short weeks, may so develop at some time as to destroy man by leaving him no food, though involving themselves in the same catastrophe.

With this in prospect, then—a struggle to the death—the work has developed, its many phases carefully watched and cared for, every possible source of aid utilized, and new methods of warfare developed. And now, after thirty-three years of long and most arduous service, age limitations, and these only, call for a change of leadership. It has been a truly wonderful record—those thirty-three years of service. This period has seen economic entomology grow from an infant to full man's size. And no one can deny that this growth has, to a large degree, followed from the studies carried on by the federal government in the bureau.

Those not connected with the bureau, and some of its members themselves, do not fully realize what has happened there, nor even what is now being accomplished, unless they put time and study upon its evolution since 1854. Those in the bureau hesitate to speak freely of their work. Only days of search, questioning and study of official records reveal the wealth of research, the mere outlines of which have been given here. To tell the story of seventy-five years in as many minutes is an almost impossible task, and to show that the record of growth and accomplishment has been a wonderful one is the most that can be expected within such time limits.

WHY DOES BUTTER KEEP?

By Dr. OTTO RAHN
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SOME readers may not agree with me when I make the broad statement that butter is one of the best keeping foods known. Of course, the term good keeping is relative. Canned goods keep almost indefinitely; properly stored apples or carrots will keep a year, while meat and fish will smell badly in a couple of days, and milk will turn sour readily, if kept under ordinary household conditions. The keeping qualities of different foods are quite distinct and not comparable. Canned goods are cooked foods, sterilized by heat, enclosed in a tin which keeps all microorganisms out; and microorganisms are almost the only cause of food deterioration. Apples and carrots are living tissues and microorganisms can not exist ordinarily on the inside of healthy living tissues. The carrots are so much alive that wounds will heal over easily and growth will start at once if sufficient moisture and temperature are allowed. Apples still have a distinct respiration, but the cells of the tissues are old. Ripe apples grow no more even under the most favorable conditions (except for the seeds), and wounds do not heal; the tissue cells have lost the power of reproduction. A wound is to the apple the open door to death more frequently than to human beings. If a mold spore gets by chance into the wound, and that is very likely to happen, the apple will be rotted in a week. But as long as the waxy skin is intact, no microorganism can penetrate and spoil the apple. Fresh meat has bacteria on the outside only, derived from its surroundings, but they gradually work their way towards the inside; and in milk, bacteria are distributed evenly through the entire liquid.

Butter is neither a living tissue nor has it a natural membrane; it is not protected by a tin, and if it were, that would not help much because bacteria are distributed all through the butter as they are in milk. And yet the Dutch, Danish and German buttermakers could manufacture butter that would keep for nine months, even before Pasteur pointed out the importance of bacteria to food decompositionn, and before artificial refrigeration was known.

Not all buttermakers could make such well-keeping butter, however. It was an art, and even now when it should be a science, it is still largely an art. It should be a science because we know sufficiently well the causes of spoilage and of keeping. It is still an art because some of the knowledge is rather new, and it takes many years before the experiments of the research workers, even of the agricultural experiment stations, are generally applied.

The theories, as well as the facts, about the keeping qualities of butter have changed considerably. A century ago, in Austria and South Germany, unsalted sweet cream butter was considered the highest delicacy, but it became rancid very readily and the market demanded the better-keeping sour cream butter. Before the age of the separator, *i.e.*, before about 1880, the milk was mostly sour by the time the cream had risen; sour cream butter was the normal butter. After the separators came into more general use, sweet cream could be obtained, but it was soured by putting in some good-tasting soured milk or buttermilk, because sour cream butter as manufactured in those days kept better. Since 1890, bacteriology was introduced

into the dairy industry. The idea of souring the cream with selected pure cultures of lactic-acid-forming bacteria was tried successfully, and was later improved upon by the preceding pasteurization of the cream. In about 1900, cold storage of butter came into more general practice, and a good deal of the summer surplus of butter was kept for winter use at temperatures below the freezing point.

Pasteurization of milk or cream is supposed to kill about 99.9 per cent. of all the bacteria. Starting with a fairly old cream with 1,000,000 bacteria per cc, after pasteurization there would be only 1,000 bacteria per cc left alive. To this cream, we add 5 per cent. of a "starter," *i.e.*, a pure culture of lactic acid bacteria with an especially good flavor. The starter contains about 1,000,000,000 bacteria per cc, and 5 per cent. of it added to the pasteurized cream would give 50,000,000 cells of the desired type against 1,000 which might possibly be harmful to butter. Since the 50,000,000 lactic organisms will produce lactic acid quite readily, they should suppress any bacteria which might cause rancidity of butter, and they should also suppress any bacteria that might get into the butter during churning, salting, working and packing. We preserve many foods by acids, either by keeping them in vinegar (sweet pickles, certain meats and fish) or by letting them sour (cheese, sauerkraut, dill pickles, brine pickles). But the theory of artificial souring, simple as it is, did not prove altogether sound. One reason for this is the spoilage of butter by molds and yeasts. That rancidity is quite commonly caused not only by bacteria like *Pseudomonas fluorescens* but also by molds and especially by *Oidium lactis* and *Cladosporium butyri*, was first shown by Orla-Jensen in 1902. These molds grow better in sour milk than in fresh milk. The same holds true with the yeasts of which some species may cause rancidity. The danger from molds and yeasts is nowadays considered greater than spoilage by bacteria, and the suggestion of the Minnesota Experiment Station to judge the keeping quality of butter and the cleanliness of the butter factory by counting only yeasts and molds is gaining in application.

All the organisms spoiling butter are easily destroyed by heat, and these organisms get into the butter after the cream is pasteurized. The greatest source of contamination is the churn. Churns are made of wood. No really satisfactory substitute has yet been found. It is almost impossible to sterilize the inside of a large churn because neither steam nor strong chemicals can be applied without destructive action upon the churn. In well-conducted creameries the churn is the greatest source of infection of the cream. But molds and even yeasts might also get into the cream from the air. Bacteria live in liquids, and can not leave their medium unless this is dried and changed to dust. Molds, however, grow on the surface of liquids, and their fruiting bodies are raised above the liquid into the air. The slightest draught will carry the ripe spores of molds anywhere. *Oidium lactis* is a common inhabitant of all creameries; it grows in the buttermilk vat, on the floors and walls and ceilings of the creamery, and wherever there is moisture and the least trace of milk left on utensils, pipes, churn, etc. Glazed tiles are used in creameries not only for good appearance; the wall covering of the churning room is of considerable importance for the keeping quality of the butter.

This infection of the pasteurized cream with bacteria, yeast and molds during further treatment was found to be an essential cause of butter spoilage. But

it is not the only cause, as was shown later. The much simpler way of keeping butter at temperatures far below freezing, to prevent any microbial activities whatever, did not prove to be a complete success either. Again and again, a good deal of the butter deteriorated in cold storage, although the bacteria, yeasts and molds decreased in numbers. Evidently this was due to some chemical action, and it was especially L. A. Rogers, of the U. S. Department of Agriculture, with several associates, who attacked the problem of butter spoilage from the chemical side. The result of these long-continued investigations was the discovery that the acid of the sour cream acts upon some substance of the butter (which was later proved by H. H. Sommer to be lecithin), producing a fishy flavor. This process is greatly accelerated by the presence of metal. Traces of metal can hardly be avoided because from the time the milk is milked into a pail until the cream leaves the ripening vat and goes into the churn, it is always in contact with metal. Rogers did not succeed in obtaining, under the most carefully guarded factory conditions, a butter free from copper and iron.

Since the acidity of the cream proved to be the main factor causing spoilage, sweet cream for storage butter was tried, and the improvement in keeping quality was so conspicuous that, during the last fifteen years, almost all butter factories in the United States changed from the manufacture of sour cream butter to sweet cream butter.

This chemical deterioration of sour cream butter had not been observed before, because at temperatures above the freezing point, microbial decomposition of butter is faster than the chemical changes. It took the cold storage butter to prove that chemical deterioration takes place at all. After this had been once established, the process was also observed in butter kept above the freezing point. The dairy industry has gradually learned to manufacture a butter that contains hardly any of the microorganisms causing rancidity. Such butter shows chemical deterioration. A very striking example of this is shown in a statistical survey of recent butter contests in Germany. The majority of first and second prizes were awarded to unsalted butter, while the contrary should be expected if we consider only the preservative (anti-bacterial) influence of the salt. The reason was this, that salt also has the catalytic effect of strongly stimulating the deterioration of lecithin by acid, as H. H. Sommer has demonstrated, and the better keeping of unsalted butter, even at fairly high temperatures, is not surprising if the butter is free from fat-decomposing microorganisms.

After this discussion, the reader might doubt even more than before the initial statement that butter keeps surprisingly well. But considering the fact that the present methods of butter manufacture make it impossible to produce butter with less than 1,000 to 10,000 microorganisms per cc, that this butter is not sterilized after manufacture, and that it is not kept in airtight containers preventing contamination, but is marketed in wooden tubs and cut and weighed in the creamery or store without any aseptic precaution, its keeping qualities are most remarkable. Compare this with the much more carefully handled meat, which is free from bacteria except on the outside and which spoils so much more readily.

The reason for the comparatively good keeping qualities of butter is its structure. Butter consists of at least 80 per cent. fat, and not more than 16 per cent. moisture, the remainder being salt and curd. The moisture consists of the but-

termilk remaining in the butter from the churning and of water from the washing of the butter immediately after churning. It is distributed in the butter in small droplets, the smallest ones being smaller than the fat globules of the milk. These droplets have been recently counted and measured by Boysen, and he found that butter contained between 10,000,000,000 and 20,000,000,000 droplets per gram of butter, most of the droplets being less than 5 μ in diameter.

This distribution of the moisture in butter accounts for its good keeping. The largest number of bacteria in butter ever recorded in literature is 57,000,000 per gram. If this number is compared with the number of moisture droplets, it becomes evident that there are not nearly enough bacteria to supply every moisture droplet. Even with the most uniform distribution, only one droplet out of two hundred can contain a bacterium, and the other 199 droplets must be free from bacteria. A computation on the basis of the averages of Boysen's counts and measurements shows that of the total moisture in butter about 99.0 per cent. must be free of bacteria if the butter contains 10,000 microorganisms per gram, and that even with 10,000,000 per gram, more than half of the moisture is free from bacteria.

It is very interesting to speculate as to how this would affect spoilage. Two theories exist about the structure of butter. Fischer and Hooker, in their book on "Fatty Degeneration" (1917), mention casually that the churning process of cream might be an inversion of phases. This means that the emulsion, which we call cream, consisting of fat dispersed in skim milk, is changed in the churn to the opposite type, to an emulsion of skim milk in fat, which we call butter. This view was accepted by Gortner and Palmer, and by Hunziker; it assumes that the moisture droplets in butter are without connection, and that fat is the continuous phase. The theory of the author claims that no inversion of phases occurs in churning, but merely a tight packing of the fat globules. According to this view, the moisture droplets in butter are nothing but spaces between the fat globules, and since the fat globules of the cream have retained their membranes, these membranes of hydrated colloid form a connection between all moisture droplets so that the hydrated colloid is the continuous phase, and each fat globule is isolated from the other. The maintenance of individuality in the fat globules of butter had been claimed by B. Storch as early as 1897, and proved to a certain degree by very good darkfield micro-photographs.

A direct decision between these two viewpoints is not possible because the connecting layers between the droplets, as shown in the illustration, are less than 0.030 μ in diameter and well beyond the limit of microscopic visibility. The main point in favor of the theory of inversion of phases is the more or less spherical form of the moisture droplets in butter. They do not appear as interstices between globules would be expected to look. The main points in favor of the author's theory are the diffusion of salt into unsalted butter and the behavior of the moisture droplets toward salt. Boysen proved by micro-cinematographic photographs that the moisture of all droplets surrounding a salt crystal in butter will move toward the crystal, dissolving the salt, while the droplets disappear altogether. Since this did not occur when salt crystals were placed into a solidified emulsion of skim milk in fat, there must be some essential difference in the structure of emulsions and of butter.

The type of this structure will affect spoilage. Dr. Boysen, together with the

author, tried to get a conception of this effect by the following method. Butter was made from cream containing lactic-acid-forming bacteria. The moisture distribution was measured; the bacteria in the buttermilk were counted. From these determinations, it was found that 26.4 per cent. of the moisture of the butter contained bacteria, and the rest was free from germs. The butter and the buttermilk were placed in the 20° C incubator, and the amount of acid formed per 100 cc of moisture in the butter, and per 100 cc of buttermilk, was determined in short intervals. Since the butter was not washed, the composition of the moisture in the butter corresponded directly to that of buttermilk; both had also the same kinds and numbers of bacteria. If they did not produce the same acidity the difference could be due only to the moisture distribution in butter. This experiment and also several others, showed that in the first two days the amount of acid formed in butter did not exceed 26.4 per cent. of the acid formed in buttermilk. But after the second day, the acidity in the butter increased beyond this percentage. The increase can be explained only by diffusion, because the assumed connecting channels between the moisture droplets are far too narrow to permit the passage of bacteria from an infected droplet to one free from bacteria. Special experiments proved that no trace of lactic acid diffused through a layer of 5 mm of fat in three months, and the increasing acid formation beyond the percentage of infected moisture speaks in favor of the assumption of a continuous watery phase in butter.

The fact that there is a considerable amount of moisture free from bacteria is independent of any theory of structure and explains some facts about the keeping of butter hitherto inexplainable. The most important is probably the effect of washing. Cream is usually churned until butter granules have developed to the size of a pinhead, or, at the utmost, that of a pea. Then the buttermilk is drained off and cold water is added, and after a few turns of the churn this water is replaced by new water, the rule being that butter should be washed until the wash water remains clear. Thirty years ago this washing process was not as universally adopted as it is now, and some dairy scientists were opposed to it. But with the present standing of technique, washed butter keeps very much better than unwashed butter. If we make a chemical analysis of such butter samples, however, we find that the washing has not removed very much of those constituents which support microbial development; namely, proteins and milk sugar. Only about half of the sugar and one fourth of the protein is washed off. In a milk diluted one half with water, bacteria would grow almost as fast as in undiluted milk. Improved keeping through washing can not, therefore, be explained on the basis of dilution of food. But it can be accounted for physically.

If we assume that butter forms through a sticking together of fat globules, the small moisture droplets are the spaces between the fat globules. This assumption is supported by the fact that the number of moisture droplets is of the same order of magnitude as that of the fat globules. Many thousands of such small droplets are contained in a butter granule of the size of a pinhead. These droplets are so firmly enclosed that wash water can not penetrate them. They continue to contain pure buttermilk. Washing removes just the buttermilk from the outside of the granules. When the butter is worked, the outside moisture forms the larger moisture droplets. Thus, we have really two different sets of moisture

droplets in butter, the small ones containing buttermilk, and the larger ones containing water. In the small droplets, each bacterium has only an exceedingly small living space, and almost the entire moisture of small droplets is free from bacteria. Of the largest droplets, each one will have a few bacteria, but they have very little food. The washing has separated the bacteria from the food. This explains the great efficiency of washing, even though the amount of protein and sugar removed is very small.

The amount of infected moisture will decrease if the number of droplets is increased, or the size of the droplets is lessened. This can be done by continued working of the butter. There is a practical limit to this, as the texture of the butter suffers from overworking; the butter becomes salvy. Comparative experiments with normal working of butter, and working to the limit, showed that, in the average, bacterial decomposition could be reduced about 40 per cent. But the greatest chances for improving the keeping qualities are in the reduction of the number of bacteria in butter; for the proportions of infected moisture for average butter are:

With 100,000	bacteria	per	gram	–12.0	per cent.
" 10,000	"	"	"	– 1.0	per cent.
" 1,000	"	"	"	– 0.02	per cent.

These deductions will not hold true for molds, because molds can force their way mechanically through such thin hindrances as fat globules. They have been found capable of perforating even thin tin-foil.

Looking back from our present knowledge to the earlier views on the prerequisites of good keeping butter, we can understand, if we remember conditions then prevalent, why washing was once considered dangerous to its keeping. The wash water in most of the small butter factories of thirty years ago was not good, and probably contained almost always *Pseudomonas fluorescens,* which makes butter rancid very readily. This bacterium is held in check by the acid produced in sour milk. Washing removed the lactose from the larger droplets and thus prevented acid-formation. Hence, washing did not improve the keeping qualities of butter until the wash water was made safe.

The same principle of growth-prevention by acid was thought to safeguard butter against most microbial attacks, and therefore souring of pasteurized cream was considered the best policy possible. Facts did not bear out this theory consistently, but the principle was adhered to until the stimulation of chemical deterioration was proved. Then sweet cream butter was churned, directly from the pasteurizer and cooler. Quite recently, a number of dairy scientists have been advising that a pure-culture 'starter' be added to the pasteurized cream, and bacteria allowed to develop sufficiently for the production of a good butter aroma, but not far enough to make acid.

Even our conceptions of the preservation of butter by salt are undergoing a change. Unquestionably, salt greatly retards microbial development, but it greatly increases chemical deterioration. As long as it was not possible to produce a butter with a very small bacteria content, salted butter kept better. Now, since the well-trained buttermaker can make a product which contains very few harmful microorganisms, the unsalted butter will keep better than salted butter.

Butter has an exceedingly interesting but also exceedingly complicated structure, and we are just beginning to understand its physical composition. A more complete understanding might possibly reverse again the methods for manufacturing a product which keeps well.

THE FORMATION OF THE ELITE

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(Translated by PROFESSOR RALPH E. OESPER, University of Cincinnati)

EVERY school gains renown not only through the scientific achievements of its professors, but also because of the industrial successes of its former students. Schools have been a potent factor in the development of an intellectual élite, the class responsible for the progress of civilization in any country. If Europe is superior to Africa, the sole cause lies in the possession of leaders. The blacks of savage countries may be good manual laborers, but they lack a select class to direct them, either as governing officials, as officers in warfare, as scholars, as engineers or as organizers of their industries. The formation of an intellectual superior class should be the dominant preoccupation of any country that expects to cut a figure in world affairs.

The geologist, de Lapparent, in a didactic statement declared that every terrain is, of necessity, divided into three strata: the upper, the middle and the lower. The intellectuals likewise may be placed on three levels: the men of genius, whose fame and influence extend throughout the world for many centuries; the great men, whose renown, however great at a given time, is finally eclipsed by that of their successors, and lastly, the lower élite, who temporarily exert a useful influence within rather narrow boundaries, but never attain far-reaching notability. Each of these three categories of intellectual superiors renders about the same volume of service to humanity; the men of genius are certainly the greatest benefactors, but they also occur most seldom. In algebraic terms, the product of the number in each class multiplied by each individual's usefulness gives a constant.

In a talk to the students of an American university Carnegie said, "I am speaking only to those of you who are ambitious to become millionaires; the others do not interest me." The present speaker wishes to emphasize a parallel thought: "I am speaking only to those of you who have an ambition to raise yourselves above the average, and I believe this will include all of you." It would surely be folly for any one to deliberately set out to become a genius, because this goal can only be reached through certain exceptional qualities, but we all can and should strive to be numbered among the élite, to use this term in its proper sense. With the exception of certain afflicted individuals, fortunately not numerous, all of us from birth have the requisite qualities. The rest is dependent on will power and on the method of developing and applying our natural endowments.

Let us examine together, using the experimental method, the conditions attendant upon the recruitment of the intellectual élite. For this purpose we need not distinguish the levels of attainment, for they do not differ in nature, but only in degree. We can then cite as examples great men with whose lives you are more familiar, and from these we may draw conclusions applicable to the formation of the ordinary élite. What qualities are essential and how may these be developed?

Activity

The most striking characteristic of great men is their zeal for work. None of them observed the eight-hour day, no matter what the field of their activities. We may cite as examples great statesmen, such as Napoleon or Louis XIV; great writers, such as Victor Hugo or Lamartine; great artists, such as Michelangelo or Leonardo da Vinci; great scientists, such as Lavoisier or Pasteur; great manufacturers, such as Bessemer or Siemens. In truth, they often employed the most varied ruses to protect their working periods from interruption. Napoleon assembled his ministerial council during the soirees at the Tuileries, leaving the reception of the guests to the Empress Josephine. Buffon took refuge in his country house and there peacefully wrote his natural history. Descartes secreted himself in a little Dutch village when he desired to cultivate his philosophical meditations. The labor expended by celebrated men is sometimes greatly underestimated. Powers of extemporaneous speaking far beyond reality are often ascribed to great orators. As a matter of fact, the most successful of them write out their addresses in full before delivering them. Mistaken notions as to this have originated from false claims. Emile Zola pretended that his voluminous literary output required only three hours' daily toil. Perhaps he did not actually keep the pen in his hand longer than that, but the final wording comprises only a small part of literary production.

Francisque Sarcey, while discussing the art of lecturing, very judicially analyzed the importance of preliminary work. He said:

> The title of a lecture should be chosen a month in advance of the delivery; then the subject matter should be considered for two weeks during every free moment, especially while strolling about. By degrees, new and interesting points of view will appear spontaneously, these should be classified either in the memory or jotted down systematically. During the third week, the material thus accumulated should be gone over mentally, the less important points rejected or suppressed, the others rearranged in their logical order and the connecting thoughts brought to light. At last, during the fourth week, the final wording is committed to paper and this requires no great effort.

Great men have not only labored much, but their efforts have been confined to a few specialties, thus increasing the intensity of their work. In hydrostatics a force is concentrated on a piston of small area in order to produce great pressures. Saint Claire Deville devoted half of his career to the study of dissociation. Berthelot worked fifteen years on organic synthesis, fifteen years on thermochemistry and fifteen years on agricultural chemistry. Many scientists owe their fame to studies made in a single field as instanced by Pasteur in microbiology, Fresnel with the theory of light, Ampere and the laws of electrodynamics. The same holds true in industrial applications and as examples we have Vicat and hydraulic cements or Fourneyron and the turbine.

This concentration of effort can not be recommended too highly to young investigators, for they frequently exhibit an opposite tendency and allow themselves to be enticed from one thing to another by topics which appeal to them. Only men of exceptional endowments, like Leonardo da Vinci or Lavoisier, can successfully distribute their efforts without paralyzing their creative powers. Some scholars carry this specialization of their endeavors to excess and pride themselves on the extent to which they disregard the obligations of daily life. Many stories in this vein are related of Ampere and of Henri Poincaré. The following actual

occurrence illustrates the same point. I was invited to dine with an illustrious foreigner and on arriving at the hotel I was told by my host that his wife was ill and consequently she could not dine with us. He said, "Under these conditions will you be kind enough to order the dinner, for since I have never studied this subject, I know nothing about such matters."

It is not sufficient to work hard, but it is also essential to work efficiently, *i.e.*, time must not be wasted on useless projects. A plan of attack should be formulated in advance of starting the actual work or writing, so that there need be no hesitation. Attempts to do two things at the same time are usually fruitless, and it should be a matter of principle not to stop working until something definite has been achieved. Learn to persevere and do not hesitate to adhere to a decision made after proper reflection. It is this spirit of organization, this convergence of efforts that is so highly manifested by great political leaders such as Louvois, Napoleon, Cavour, Mussolini.

Much gain may accrue by organizing the vague, spontaneous thoughts which the mind can not suppress, even though they appear to have little value. We are always thinking about something, and this involuntary thought is much less fatiguing than mental effort consciously directed toward definite production. This preparatory reflection is sometimes erroneously regarded as being quite distinct from the real work, but this opinion is quite wrong, for preliminary thought is an essential forerunner of all creative achievement. In fact, it is just as indispensable as the final effort and the latter will certainly be of little avail if the way has not been properly prepared. If the mind could be trained not to think useless thoughts, the productive capacity would be enormously enhanced. When Newton was asked how he had discovered the laws of universal attraction, he replied: "By always thinking about them." This may be the dominant reason for the superiority of great men, but we really know very little about this fugitive thinking, whose manifestations are not external. In fact, the originators of such mental processes are sometimes not conscious of their operation, or, as we say, we are here dealing with the subconscious. Henri Poincaré claimed that he thought during sleep, and on waking would find at hand the solution of problems which had baffled him the day before. However, this is not a commendable practice, for it is opposed to the rest which each night's sleep should bring.

How may a zeal for work be developed? Is it a natural gift or is it a result of education? The greatest stimulant of activity is habit, which proverbially becomes second nature. After leading an active life, it is not possible to stop work without suffering. Idleness due to retirement rapidly kills many men who previously had enjoyed excellent health. After the habit of working is once formed, a man will work for the mere joy of working just as we walk for the pleasure of the exercise. It has become a necessity.

However, this habit is not easily acquired. Temperament plays some part. Certain children, from birth on, exhibit more will power, have more acute faculties of attention, are more persevering, all of which are essential to the accomplishment of a protracted task. Yet these predispositions are, in general, developed only to a slight degree and play only a minor part in the differentiation of individuals. Other factors seem to be of greater importance.

The example of the home and of companions exercises a preponderant influence. A child who all his life has seen an industrious father will merely through imitation be led to accept the law of the obligation to work. Pascal, Lavoisier, Pasteur were raised in families in which honor was paid to industry. Whether the latter is intellectual or manual matters little. Very few, or perhaps no great men, have come from the families of the idle rich.

A second very potent factor is ambition, that is the desire to acquire riches or honors. Men not favored by the fortunes of birth sometimes struggle with extreme energy to make a place for themselves. A striking instance of the power of ambition is found in the career of Senator Leopold Goirand, who died recently. He published some essays on education which reveal curious points in his psychological makeup. At the age of fifteen, he conceived the dual ambition to become very rich and to attain a powerful political position. He succeeded in both endeavors. For twenty years he forced himself to be content with six hours of sleep each night in order to lengthen his working day. Each morning on arising he spent two hours acquiring general culture, the rest of the day was devoted to his business, and finally the evenings were passed in attendance on social affairs, for the latter are extremely useful in the prosecution of a career. Not until his physician warned him that he was no longer fit to continue this program did he consent to sleep eight hours nightly. Many similar examples may be cited.

In Bessemer's autobiography, which is a veritable romance, he tells of his superhuman efforts, as a young man, to earn enough money to marry. While Cavour was striving to create the Italian kingdom, he allowed himself only five hours' sleep each night so that he might have time for the stupendous task whose realization had been the dream of his whole life. He took over the direction of four ministries at one time.

A third stimulus, more noble than those already discussed, is the attraction inherent in the fruits of labor, *i.e.*, the joy of knowledge and the pleasure of performance. The passion for knowledge or for success in a chosen field often arouses men who by temperament or habit might have been inclined to loaf. A pertinent example is Mallard, one of the scientific glories of France. Like many others who graduated from the Ecole Polytechnique at the top of the class he seemed to be destined for a standardized, peaceful career in the governmental service. As engineer at Gueret and then as professor at Saint Etienne he divided his activity between long journeys and everyday affairs, attending to his administrative duties and his teaching. At the age of forty he was appointed professor of mineralogy in the School of Mines in Paris, and consequently because of his teaching duties he found himself obliged to study this science. He became deeply interested in one of its branches, crystallography, and for twenty years, until his death, all his efforts were concentrated in this field. He succeeded in working out original demonstrations of the laws of crystallography and he created a new chapter in this field, the theory of crystalline groupings.

Many similar cases are found among scholars, for many of them are motivated chiefly by the joy of knowledge. On the other hand, examples of this disinterested activity are less frequent among industrialists. However, the pleasure of achievement rather than the mere love of gain has actuated the

greatest of these. The optician Zeiss worked for the glory of his country, Germany, and his native city, Jena. The Danish brewer Jacobsen engaged in business only to gain the means of endowing the museums and laboratories of Copenhagen, which have become world famous. The American millionaire Carnegie while a young man spent his free time in libraries solely because of his desire to learn. He later devoted the major portion of his immense wealth to the development of public libraries and to the founding of an institute of scientific research. Henry Ford left the farm and worked in a locksmith's establishment because of a desire to learn the use of tools, and even now he continues in business because he derives great pleasure from heading a well-organized industry. I knew two contractors who had taken part in the construction of the Suez Canal. They retired from business and took up agriculture. One engaged in stock-raising, the other developed a model farm. They devoted all their energies to the enterprises and ran them so that the receipts and expenses balanced, neither profit nor loss resulting. Their sole ambition was to do a good piece of work and to turn out products of superior quality.

This joy in work may be developed by education and without difficulty. Success is assured if less attention is given to preparing for examinations and more stress laid on the intellectual molding of the children. From their earliest years they have a wide-awake curiosity, they continually ask why and how. Instead of eradicating this disposition, it should be cultivated. Science courses lend themselves wonderfully to this end. Emphasis should be placed on the linking together of facts, which is the essence of the scientific method, discarding the fastidious enumeration of isolated facts which so overburden the memories of pupils to-day. Any child can be interested in the consequences of Pascal's laws of hydrostatics and made anxious to work diligently to understand them. A study of Archimedes' principle, applied to floating bodies, of hydrometers, of water levels in connecting vessels, of atmospheric pressure—all these may be grouped around Pascal's laws and thus made into an attractive ensemble. It is wrong to treat each of these topics as a separate chapter as many physics texts do, for then the intimate relationships disappear from view and likewise all attractiveness is lost.

Manual exercises should be included in the secondary curriculum because the formation of ideas in young people is rendered more easy and pleasant by combining sight and touch. They love motion. For instance, when teaching hydrostatics, the pupils may be directed to cut cubes from various kinds of wood, to measure them, to weigh them and finally to determine the loss in weight when the cubes are immersed in water. An exercise of this kind makes the appreciation of Archimedes' principle pleasurable. In the same way, preliminary exercises in graphic plan-making lead to a much easier understanding of geometrical reasoning. Much less intellectual effort is required to comprehend the demonstration of a truth if actual experimentation has previously made the reality familiar.

A final incentive to the ardor for work is good health. The thought of working or still more of getting to work, *i.e.*, the wish to do something, involves, if not a true fatigue, at least a feeling of fatigue which leads many to shrink back. A good digestion and restful sleep make the thought of work much more agreeable. This does not

imply that a strong will can not overcome the weakness arising from poor health, for there are remarkable instances of such victories, but they are rather exceptional. Pascal subdued his infirmities, but the strain finally killed him. Health always is a great driving power, and the truth of the axiom, "*mens sana in corpore sano,*" can not be debated. Physical culture should occupy an important place in the education of the young; it is indispensable in the formation of the intellectual élite of a nation. However, it must not be forgotten that muscular fatigue renders all mental labor impossible for the time being. The physical exercise should follow intellectual exertion, but should never precede. While in Holland, Descartes devoted his mornings to philosophy and cultivated his garden in the afternoons.

Imagination

A useful member of society does not merely work hard and produce much for his own benefit; he should add to the common fund of knowledge. In other words, he must produce new ideas, discover scientific laws, devise new literary or artistic presentations, perfect methods of government; in short, he must play a creative rôle.

What is the mechanism by which this progress is realized? Contrary to popular belief, our knowledge does not increase by leaps and bounds, but the development is regular and very slow. Each step forward, in the majority of cases, comes from the simple combination of facts previously known. It is only necessary to delve in the storehouse of knowledge and to bring new relations to light. This correlation is a fruit of the mental faculty, imagination, whose functioning is rather capricious. The solution of a problem may be sought unsuccessfully for a long time, and then suddenly it may flash into the mind at a time when the problem is no longer being consciously considered.

The work of all great men shows the employment of imagination; it constitutes the beginning of all great discoveries. Pascal created hydrostatics by connecting the limitation of the height of a barometric column with the weight of the atmosphere; Newton discovered universal gravitation by comparing the movement of the planets with the fall of an apple; Pasteur founded microbiology by connecting the spread of disease with the life processes of microscopic organisms. Likewise, in the field of letters, we find writers dealing with ideas common to all humanity and sending them forth in new attire. La Fontaine gave life to Aesop's fables by endowing the animals with speech; Corneille introduced a sense of duty magnified almost to heroism into the Spanish dramas. Artists sometimes slightly exaggerate certain features of their models to produce a more striking representation. Michelangelo accentuated the muscular development of heroic figures and Raphael the grace of women.

The same is true in industry. Sir William Siemens applied the theoretical reasoning of Sadi-Carnot to the heating of hearths, and the regenerative furnace resulted. He invented neither thermodynamics nor industrial heating, but by uniting these two sets of facts, he brought about a great advance, which made possible the modern processes of making steel in open hearths and of glass in tank furnaces. All inventors possess this mental activity, sometimes to excess. It is interesting to read Bessemer's autobiography from this point of view. We see his mind always in feverish agitation, trying each day to produce something new, usually without success.

This first type of imagination is meditative. It acts slowly, and to a certain degree may be governed by the will. There is a second type, rather more delicate in nature, whose action is sudden and not preceded by reflection. It is this type which enables us to see at a glance all the correlations and distant consequences of a chance observation. The predisposing factors are impressionability and nervous sensibility. This quality varies greatly from individual to individual, certain minds respond to the slightest external suggestion, while others feel nothing, see nothing. In general, great scholars are characterized by a highly developed aptitude for sensing and using facts presented to them. The accidental observation that his determinations of the density of nitrogen were discordant led Lord Rayleigh to the discovery of argon. Other investigators had been faced with the same phenomenon, but were not markedly impressed. While attempting to fuse platinum, Saint Claire Deville was struck by the difference between the calculated temperature of the oxy-hydrogen flame and the observed melting point of platinum. This led him to suspect the dissociation of water vapor, while his collaborators, possessed of the same facts, thought nothing of them. Similarly, Bessemer was led to his process of producing steel in a converter by the fortuitous observation of the formation of malleable steel during an attempt to harden cast iron. Or better still, Auer von Welsbach discovered the incandescent mantle through a chance observation of the light emitted on calcination of precipitated thoria. Numerous analytical chemists had doubtless seen the same thing, but their attention was not arrested.

Great artists viewing nature, great generals before a battle, great lawyers before a trial are sensible to instantaneous impressions which escape the notice of ordinary men. The two types of intellectual activity seem to be predominantly natural endowments. Some children have wide-awake minds, others are more dull and remain thus throughout life.

This quality may, however, be developed by education, and more attention should be paid to this phase of education than is usually the case. Exercises in written composition, problems in geometry, afford excellent material from which to build up mental habits of using accumulated knowledge or of seeking new correlations of known facts. This type of training is doubtless the most useful function of secondary education. On the other hand, education can not develop the second type of mental activity which is not dependent on reflection, but which functions instantly in some way not known to us. Nevertheless, there seems to be some possibility of perfecting this natural endowment by suitable laboratory exercises.

Judgment

The combining of imagination and work, *i.e.*, intellectual activity joined to bodily activity, does not entirely suffice for the making of a great man. Excellent examples are inventors, who almost without exception are possessed of active minds and an equal ardor for work, and yet few of them become great. In fact, many of them have difficulty in making both ends meet and remain mediocrities. The two qualities can only be used efficiently if joined with a third, namely, common sense. This latter, if developed to its highest degree, becomes what Pascal has called the sense of finesse. Bodily and mental activity are certainly powerful instruments, but like all aids they must be

used judiciously. Common sense should guide the choice of problems to be studied.

One of the most potent reasons for the success of great men is that they were wise enough to apply their efforts to worth-while problems. Why will the names of Lavoisier, Sadi-Carnot, Ampere, Fresnel, Saint Claire Deville, Berthelot always be famous? It is because of the greatness of the topics they studied. The results of their discoveries in chemistry, thermodynamics, electrodynamics, physical optics, chemical mechanics, organic synthesis have echoed again and again, and the reverberations are daily multiplied.

Many years ago Taine said that the systematic study of the dominant features of his subject was the essential characteristic of the work of a true artist. The same holds true in all realms of human activity. There are dominant phenomena whose influence is felt under most manifold circumstances. A knowledge of these favoring factors is of inestimable value to the human race, and their discoverers merit suitable recognition on the part of their fellowmen.

A second form of judgment is "critical sense," indispensable to both scholar and to those directing industries. This gift makes possible the detection of errors in measurements or leads to a premonition against erroneous interpretations of observations. It is often lacking in inventors, who are prone to persist in their notions despite self-evident failures. Lesser intellectual lights also can not bring themselves to abandon favorite hypotheses which are not in agreement with the facts; they seek refuge in new additional hypotheses and cling fast to the original notion. Ditte, a pupil of Saint Claire Deville, furnished a striking example of this type of mental gymnastics. While trying to extend the law of fixed dissociation tensions to the decomposition of solutions of mercuric sulfate he found that the concentration of the liquid with respect to sulfuric acid increased with increasing concentration of mercuric sulfate. Instead of abandoning his hypothesis, which was obviously inaccurate, he introduced a second, which to-day appears absurd, but for a time it enjoyed a certain credence among chemists. He postulated that the dissolved mercuric sulfate was present in two forms, part as neutral salt and part as basic salt, dissolved in, but not combined with, sulfuric acid. He calculated the proportion of the basic salt supposedly thus dissolved which would leave a constant concentration of sulfuric acid in solution, and he viewed the results of this arbitrary calculation as experimental verification of his hypothesis. This species of error is constantly perpetrated nowadays by those who speculate as to the constitution of matter. Savants who, like Lavoisier, Claude Bernard, Pasteur, combine an ever-watchful imagination with a critical sense severe enough to lead them to discard hypotheses found contrary to fact are extremely rare.

Finally, there is a still more refined form of common sense, namely, the sense of subtle discrimination which enables us to guide our minds directly into domains of thought which are not perfectly obvious. It is often asserted that hypotheses are free to all, an investigator may postulate what he pleases, provided he finally subjects his notions to precise, experimental test. However, it is distinctly worth while not to set up too many inexact hypotheses, for time should be economized to the end that production may be increased. A certain instinctive discernment is necessary to set one rapidly on the best line of procedure. Rules for

this can not be laid down; it is a matter of feeling and not of reason. The remarkable productivity of Pasteur was doubtless due to his ability, from the very first, to thoroughly organize his researches. Sometimes this ability is ascribed to chance, but this is not correct, for we see here the fruit of a very shrewd form of common sense. Saint Claire Deville's thought that there might be a possible analogy between the phenomena of decomposition and those of vaporization was an intuition of genius; it led him to the discovery of chemical equilibrium, which he termed dissociation, and a new science, chemical mechanics, has been erected on this idea.

Good common sense is often a gift of nature, but the more delicate sense of subtle discrimination is principally a result of education. It is very rarely observed among the children of the lower grades; it is a product of classical education, and, above all, it springs from that which is taught in the home. The English declare that thirty-six years of education are necessary to make a gentleman, twelve for the grandfather, twelve for the father and twelve for the son. The same holds true for this sense of finesse. Pascal, Lavoisier, scholars of the first rank, came from families of long-standing culture, and their successes were due in large measure to the prolonged efforts of their ancestors.

The study of classics and humanities aids in developing this trait. Literary or historical criticism requires a constant evaluation of opposing points of view to determine the part played by each in domains not amenable to exact measurement. On the other hand, the study of science develops the geometrical viewpoint, *i.e.*, the use of syllogism, which is utterly useless when comparing phenomena possessing no common measure or such as are based on mere probabilities. The exclusive use of rigorous reasoning and an absolute faith in his conclusions are sometimes very dangerous to a savant. They hinder him from taking account of the real value of the hypotheses which he has made and from recognizing the possible errors in his experiments. These modes of thought are not less hazardous to the industrialist to whom they may impart an unwarranted confidence in the predictions as to the advantages of a new business venture or of a new method of manufacture.

Documentation

Many of the essentials for laying claim to a right to be numbered among the intellectual élite have been discussed above, but not all. Suppose that a savage has had from birth all the qualities which we have just reviewed, but that he is entirely ignorant of the progress of the science and industry of the civilized world. It would be extremely difficult for him to advance our knowledge, for he knows nothing about such matters. He can accomplish feats which to him seem extraordinarily difficult, such as cutting flint or extracting iron from ores, just as his ancestors did. To us, however, he would seem ignorant and no one would dream of classing him as a great man.

No one can make innovations or improve our knowledge unless he is cognizant of actual conditions. There are several reasons why this is so. In the first place, one can obviously improve only those things which he really knows. A frequent cause of the failure of inventors is that they knowingly venture into unfamiliar fields. Bessemer, the son of a metallurgist, advanced the science of metallurgy, but made a miserable failure when he attempted to build a large telescope and also when he tried to construct a boat designed to prevent

seasickness, because he knew little or nothing about the theory of optical instruments or of mechanical principles.

While serving on a commission appointed to investigate fire damp, I met a physician, intelligent, possessed of a good practice, but obsessed by the demon of invention. Much affected by an explosion in which several hundred miners had been killed, he thought it would be a good thing to send a current of air through the mine to sweep out the explosive gases and thus obviate such disasters. He disclosed his plan to an official in the Department of Public Works, and the latter warmly congratulated him on his initiative. This unfortunate encouragement led him to abandon his practice for a year and he devoted himself to the construction of a ventilating system. We were obliged to inform him that every coal mine in the world is ventilated. Furthermore, twenty kilometers from his home he could have seen in action immense installations which closely resembled the blowing apparatus which he had worked out, and this device differed but slightly from the bellows used for several thousands of years by savages for melting metals.

A second reason for being well acquainted with the field arises from the fact that all creative advances, all discoveries are, for the most part, the result of combining facts already known. The progress achieved by a single individual is, in general, extremely little, but among these short steps forward, one perhaps, like the last drop which causes the vessel to overflow, may make an invention realizable or it may alter the orientation of our scientific ideas.

Pasteur did not invent the communication of diseases, for this was known to all physicians, nor did he discover the existence of living microscopic organisms, which had been studied from the time of Spallanzani. He merely compared these two sets of phenomena and recognized their relations one to the other. Had he not known the facts, he could not have made the discovery. Likewise, Lavoisier did not invent the balance; it had often been used before. Every alchemist who extracted metals from ores had checked the efficiency of his procedures by weighing. On the other hand, all physicists knew that gases had weight. Lavoisier simply had to combine these facts to recognize that the increase in weight of metals when calcined in the air was due to the absorption of a gas, oxygen. The time was ripe for this discovery, and Lavoisier had only to pluck the ripened fruit.

The same holds true in industry. The open hearth process of making steel resulted from a combination of Réaumur's century-old work on the refining of cast iron and Siemen's new method of heating. In his invention of the incandescent gas mantle, von Welsbach started with Clamond's magnesia "basket" and perfected this device by substituting thoria for the magnesia. This linkage of known facts is so common that no industrial invention is so novel that the lawers can not find authorities for prior claims. For the same reason, the defamers of great scholars, great writers and great painters find great pleasure in accusing them of plagiarism. Fontaine has been reproached with having copied from Aesop, and Corneille is accused of servile imitation of Guillen de Castro.

If the popular saying, "There is nothing new under the sun," is surely not strictly true, nevertheless it is quite accurate to state that progress due to any one man is comparatively small. Humanity moves forward at a slow pace, but the thousand-fold accumula-

tion of short steps forward has altered the face of the world. This progressive revolution has only been possible because men have had a thorough knowledge of the accomplishments of their predecessors.

A third reason for being well versed is that accomplishment of anything new demands a knowledge of the technique of the field, and this has to be learned. If Bessemer had not been a founder in his youth he would never have invented his process of making steel. A thorough knowledge of analytical chemistry is essential to the making of chemical discoveries; success in literature is only possible to one who really knows his own language; a painter must know how to draw. This assertion may appear to be a step backward. Too many artists try to paint, knowing neither drawing nor manipulation of colors; too many scientists have no interest in methods involving actual measurements, they are content to construct their science with pencil and paper only. These varieties of modern painting and science are very fruitful for their devotees. However, who dares to assert that the cubists and similar faddists will some day be classed as great painters or that much of our present-day theories of the constitution of matter will be highly regarded fifty years from now. In comparison, the men who discovered new laws in chemistry, electricity, optics, etc., will be just as honored thousands of years hence, as Pythagoras, Ptolemy and Archimedes now are.

This knowledge of the field, essential to any worker who hopes to advance human welfare, may be acquired through instruction furnished by schools of all grades, from the highest to the lowest, or it may be a result of observation of the facts, *i.e.*, a fruit of the direct study of the surroundings in which we live.

No one is born with a knowledge of the outer world; this must be acquired solely from experience and toil. Certain natural endowments, memory in particular, favor the acquisition of this necessary knowledge. Many great men have had remarkable memories; Berthelot and President Poincaré are outstanding instances. The former knew the title of more than a thousand of his papers and the volume numbers of the Annales de Chimie in which they were published. It is said that Poincaré needed only to write a speech once to know it by heart. He amazed his audience at the Sorbonne by his delivery of a eulogy of the scientific achievements of Berthelot. He spoke more than an hour and a quarter, using no notes or memoranda, and yet with such precision that any one might have thought him an exceptionally well-informed chemist.

The sense of observation is no less valuable; it is essential to the completion of the fragmentary knowledge acquired by the memory during the years of schooling. As we go through life, we are confronted by a multiplicity of facts which demand our attention and efforts. They are so numerous that we can not expect to learn them from books, and, furthermore, many of them are not common knowledge and consequently can not be found in courses of instruction. Our knowledge of the world is constantly augmented by the labor of every one of us, but the contributions are extremely unequal, varying with aptitude and training. In military instruction, observation is taught by assignments in scouting. The pupil is sent to a given point and on his return he is questioned as to what he saw. Usually, he has seen nothing. He is sent back and told what to look for: the undulations of the ground, the kind of vegetation, isolated trees, hedgerows, roads, houses, the con-

tour of the horizon, and little by little the pupil improves.

High-school exercises in science should be largely planned to develop observational powers. Actual handling of apparatus and materials lends itself excellently to this end. A student is told to heat a material, say iodine, in a test tube, or to dissolve a substance, mercuric sulfate, for instance, in water, and then asked to describe all that he has seen. After he has completed his report, the instructor should point out all that actually can be observed in the experiment.

Conclusion

To sum up, we find that the formation of an intellectual élite entails the union of four qualities—industry, imagination, judgment, training. Unfortunately, these qualities are, in a certain degree, contradictory among themselves. The toiler, bound to his task like an ox to a cart, often forgets to pause and meditate; his intellectual activity slows down. The dreamer, the inventor lets himself be guided by his fancies and often lacks common sense. Finally, the abuse of book learning and memory tends to paralyze all the intellectual faculties.

It is extremely difficult to produce a perfect balancing of these diverse faculties. This fact alone is sufficient to explain the infrequency of great men and, *a fortiori,* of men of genius. It is useless to suppose, as many do, that men of genius owe their accomplishments solely to exceptional natural endowments which raise them above the common level. They have qualities which taken singly are not extraordinary, but it is the occurrence of all these qualities in a single mind that is rare.

Most men do not like to work. The suburbs of Paris are filled with small houses inhabited by rentiers, who perhaps in the beginning worked hard but only in the hope of soon being able to stop working. Unfortunately, this feeling is all too general in the Latin countries. In 1918, during the Armistice, a party of American engineers who had served as officers were taken for a boat ride down the Seine from Paris to Rouen to see the bridges, locks, etc. To them, the most striking sight was the number of fishermen lining the banks of the river. They could not believe that there were so many Frenchmen content to spend their days watching a cork float on the water, thinking nothing, doing nothing.

Intellectual industry is not much more common than bodily industry. One needs only to scan the interminable lists of candidates for petty government positions which require little, if any, mental exertion. The holders of such offices are content to repeat each day exactly what was done the day before. This apathy is apparent from childhood on. How many college students have a horror of real effort? They are satisfied to learn assigned lessons by rote, and never do more than the required amount. Indeed, they often do not try to understand what they learn.

Common sense is perhaps rarer still. In proof of this, consider the results of popular elections. The voters work painfully to make their livings and then cast their ballots for the worst wasters of the public wealth. Industrial conflicts lead to mutual ruination; efforts to squeeze the consumer, who is the goose that produces the golden eggs, bear witness to this same stupidity. Each side devotes itself to efforts to bring about a redistribution of wealth, each hoping to get the bigger share. Neither party comprehends the real problem, which should be its sole interest, *i.e.,* they should both strive for in-

creased production, which would benefit the world at large.

Finally, the question of learning what has been done and the matter of instruction and training is still in a precarious condition. The number of illiterates is still very large. Schools are often more concerned with politics and large enrollments than with the pupils. Unfortunately, this is one of the habitual wastes of democracies. In the higher schools, students obtain cheapened degrees, and higher culture is regarded with more and more contempt. The fetish of equality means a levelling on a lower plane.

Admitting what has been said, let us make a calculation. Suppose one man in ten has a love of industry; one in ten a certain intellectual activity; one in ten common sense; one in ten has been well taught. The probability that these four qualities will be found in one individual will be $(\frac{1}{10})^4$ or $\frac{1}{10,000}$, *i.e.*, one in ten thousand may be expected to belong to the intellectual élite. This is not many. The production of a great man requires the union of these same qualities, but each in full bloom. If each quality, developed to this high degree, occurs in one man in a hundred, the probability of their being thus present in a single individual is $(\frac{1}{100})^4$ or one in a hundred million. Consequently, we can explain why men of genius are so rare, without seeking the reason in the realms of wonder.

It is a very noble task to aid in the creation of an intellectual aristocracy. The prosperity and lasting glory of any country, all its future welfare, depend on the success of these efforts. Above all, this is a work of education, and no effort should be spared to realize this common good. The family should set a good example to the younger children and inculcate a taste for toil; the secondary school must develop imagination and common sense; and finally the colleges and universities must impart training.

However, an intellectual élite is not the only thing required to make a great nation. There must also be a moral élite, a great class which knows respect for the rights of others, a class to whom the Golden Rule is law, and last but not least, this class also respects and demands respect for real liberty. I do not wish to discuss this last point in detail, for it lies outside my province, and especially because we have a right to expect that the educated classes will have both a highly developed sense of duty and a profound appreciation of independence. It is their duty and privilege to set a noble example to others.

RACE CROSSING IN JAMAICA[1]

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As one travels over the world one sees that the people who inhabit its different parts differ. Thus one gets the notion that the world is inhabited by different races.

An attempt to define "race," however, is fraught with many difficulties. The difficulties are diminished by accepting the definition of students of genetics, which is as follows: A race is a group of individuals constituting a subdivision of the species characterized by the possession of some one distinctive hereditary trait. Thus, from this point of view, a blue-eyed Swede belongs to a different race from a dark-eyed Italian or even from a dark-eyed though blond-haired Swede, since eye color is an inherited trait.

Race connotes, however, a *group* of individuals having at least one and the same differential, hereditary trait. A century or two ago such human groups were found in different parts of the world fairly sharply marked off from each other. The Congo region was characterized by a group of persons with black skin, broad nose, closely coiled hair which marked them off from the Scandinavians with slightly pigmented skin, blue eyes, narrow nose and straight hair; also from the yellow-skinned, black-eyed Chinese with their small, almost bridgeless noses and from the inhabitants of the Hawaiian Islands, of great stature, light, but easily bronzed skin, wavy hair and high-bridged nose.

To-day, things are much changed. Into the Hawaiian Islands, for example, have been brought Chinese, Japanese, Filipinos, Portuguese, English and other races, who have intermingled with the Polynesians until pure-blooded representatives of the latter are becoming scarce. The race of North American Indians has for three centuries been in contact with European stocks and in these United States few of them are left of pure blood. Central Africa is being penetrated by Europeans, as it has been for centuries by Arabians and Jews, and it will be only a few score years before pure representatives of the Negro race also will be hard to find. The Negroes which were imported to the Americas have largely hybridized with the whites and Indians. The standard races of mankind are rapidly disintegrating. For race implies a certain amount of isolation under cover of which it can develop, but in these days of rapid transportation to all parts of the globe isolation is no longer possible.

Those who look to the future are naturally concerned with the question: What is to be the consequence of this racial intermingling? Especially we of the white race, proud of its achievement in the past, are eagerly questioning the consequences of mixing our blood with that of other races who have made less advancement in science and the arts. Is it possible to predict the consequences of such racial intermingling? Is there any reason for thinking that hybridization, such as is going on even among the races of Europe, leads to an inferiority of the offspring?

To-day, as never before, we are in a position to make investigations that may throw light upon this subject. First, because racial intermingling is so widely occurring and, secondly, because the technique of the study of race crossing has been worked out by the geneticists,

[1] Address delivered in April, 1928, at the Carnegie Institution of Washington, Washington, D. C.

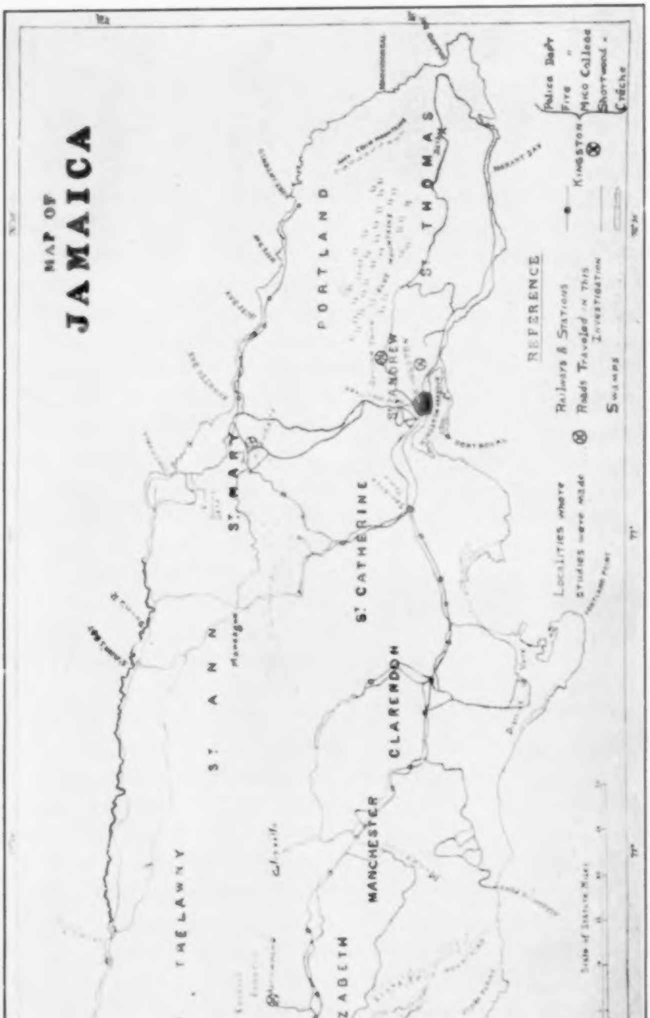


FIG. 1. MAP OF JAMAICA

SHOWING PLACES WHERE POPULATION WAS EXAMINED.

FIG. 2. a, b, NEGRO FACES; c, FACE OF A BROWN (MULATTO)

proceeding along experimental lines. The unexampled progress in the study of heredity in the last twenty-five years is due to systematic experiments in crossing of distinct races and studying the distribution of the racial traits in the first, second, third and later generations following the cross.

Genetical experimentation in hybridization has revealed several general principles. One is the fact that the inheritable traits do not ordinarily permanently blend in the offspring, but some of them tend to recur in their pristine purity in later generations. The principle of segregation of traits has become well established. It is recognized, however, that such segregation is the more obvious and the more complete the simpler the genetic constitution of the trait in question. If the trait is composite, composed of two or more elements, then segregation is less clear and the course of inheritance is, in general, complicated and sometimes "blending."

Another principle that has been established is that of heterosis or the hybrid vigor observed in the first generation in the offspring of a hybrid mating. This is best seen in the first generation, but its consequences are found scattered among individuals in later generations. A familiar example of such hybrid vigor is the mule, which is more vigorous than either of the parental species involved.

Still another principle observed in some cases is that of diminished efficiency of certain hybrids, owing to a conflict of instincts. Such dog-hybrids as that resulting from a cross between a collie and a terrier, or hybrids of poultry between an egg-laying and a periodically broody strain are of little value. In these cases the hybrids have lost the remarkable and valuable sets of instincts that have been built up through generations of careful breeding and are markedly inferior to either of the highly bred parental stocks.

In order to make a comparative study of the efficiency of a hybrid race and the two parental stocks from which it was derived the Carnegie Institution of Washington accepted a gift made to it and undertook a study of the topic of Negro-white crosses in the island of Jamaica, British West Indies.

The island of Jamaica (Fig. 1) is particularly well adapted to such a study, partly because there still exists a fair proportion of pure-blooded representatives of both the white and the Negro races, as well as a large number of hybrids between these races. The population speaks English and is socially so well organized as to be readily accessible

FIG. 3. a and b, BLACK MAN AND WOMAN
FROM THE MAROON TOWN OF ACCOMPONG. NOTE FACIAL FEATURES, HAIR, DISTANCE BETWEEN EYES.

c and d, BLACK MAN AND WOMAN
OF GORDON-TOWN, AN AGRICULTURAL COMMUNITY NEAR JAMAICA.

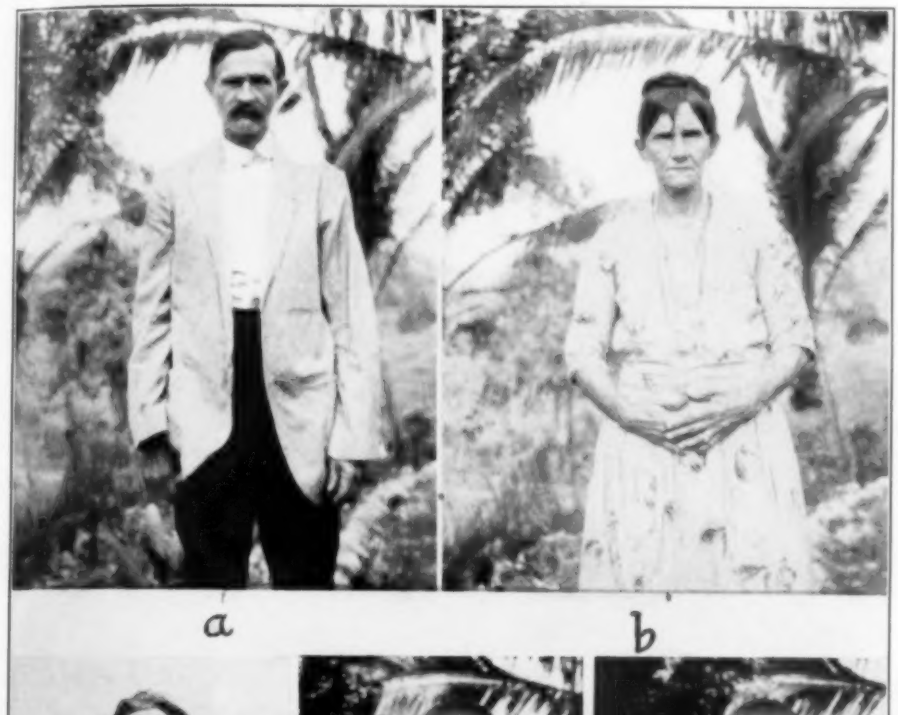
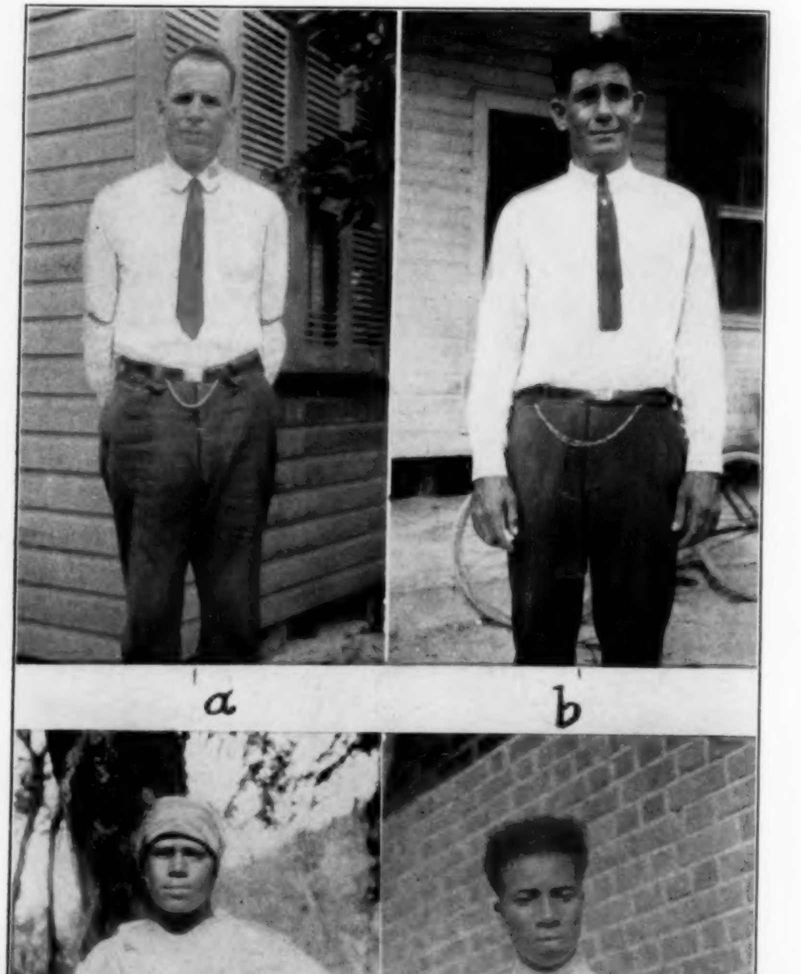


FIG. 4. EXAMPLES OF THE WHITE POPULATION OF SEAFORD TOWN
a, b, MAN AND WIFE. NOTE SHORT INTEROCULAR DISTANCE, LONG NARROW NOSE. c, SON OF MAN AND WIFE, ABOVE. d, e, SISTERS, SHOWING RESEMBLANCE CHARACTERISTIC OF AN INBRED COMMUNITY.



c d

FIG. 5. a, b, TWO GRAND CAYMAN ISLANDERS
NOTE TALL STATURE, NARROW FACE, LONG SLENDER NOSE.

c, d, TWO BROWNS
c, MARKET WOMAN OF GORDON-TOWN; d, STUDENT AT MICO COLLEGE.

to the investigation. We were fortunate in being able to put the work of collecting data into the hands of Mr. Morris Steggerda, who proved himself excellently fitted for the work. To carry out the program of the committee in charge of the investigation it was necessary to study carefully one hundred full-blooded Negroes—male and female—called hereafter "Blacks"; one hundred white people and one hundred mixtures between the two races—whom we may call Browns. To make the two groups comparable it was necessary to take them, as far as possible, from the same social stratum.

It was fairly easy to find full-blooded Blacks, especially in the so-called Maroon towns, such as Accompong in the West (Figs. 1; 3, a, b), to which the Negro slaves retreated many generations ago when the English seized the island from the Spanish. Many are found in farming communities of the island whose whole appearance supports their contention that they are of pure African stock (Fig. 2, c, d).

It was much more difficult to find persons of unmixed white stock living as agriculturalists in an island composed of 98 per cent. colored persons. Fortunately for our study, there is a group of Germans whose ancestors were brought to this island about four or five generations ago and which is now living at Seaford Town in the west center. This is an isolated white community, who have carefully preserved their genealogical records (Fig. 4).

But we were not able to get enough adult whites at Seaford Town, and so studies were made at Grand Cayman Island, a two days' sail to the westward of Jamaica. Here is a group of whites of English stock, rather taller than the German folk of Seaford Town (Fig. 5, a, b).

Brown (or hybrid) people it was easy to get in the required number. Some of these were agriculturalists at Gordon Town near Kingston (St. Andrew) and elsewhere (Fig. 5, c). Rather more than were desirable were studied at the training schools for teachers—both those for men and those for women—for these brought into the statistics a lot of non-agricultural people (Fig. 5, d).

Studies were made also on children; both babies at the creches, or day nurseries in Kingston, and school children from eight to sixteen years of age. The open-air schools that abound in the island offered good shelter and excellent light for the measurements and tests.

The results of this study have now been brought together.

One of the first questions raised in the study of race mixtures is that of variability. This question is of particular interest at the present moment through the circumstance that Dr. M. J. Herskovits, who has studied many Negroes in the United States, has reached the conclusion that they show a reduced variability, as compared with the white. This is opposed to the expectation, based upon genetical experimentation, that in the second hybrid generation there is increased variability. This increased variability is found, however, only when the original races are of very pure stock. Also, the increased variability is found just in those traits in which the original stocks differ. Moreover, if there are many of such dissimilar traits, the hybrids may differ from each other in presenting new combinations of such traits.

As stated, Herskovits has found that the Negro mixtures are not, in general, highly variable. For example, he has shown that they are not more, but less, variable in stature than a lot of whites measured in different parts of the country. This, however, is not to be wondered at because, on the average, the Negroes and the whites of the United States have the same stature. Variability comes about when the racial traits differ by at least one gene. Under those circumstances the offspring may

possess, or lack, the gene and, accordingly, may possess, or lack, the trait whose development depends on that gene. Now there is no reason for supposing that there is any difference in the genes that are responsible for the stature of the average white and the average Negro, or if there are differences in the genes they do not affect stature as a whole but merely elements which go to its make-up. In studying variability of hybrids we must focus attention upon traits in which the original races differ by one or more genes.

Gene differences between races are recognized as such partly by an important difference in mean size of the trait and partly by the behavior of the trait in hybridization. If we consider the breadth of the nose we have a trait which is genetically different in the white and Negro races. The hybrids

TABLE A

PROPORTIONAL DISTRIBUTIONS OF NASAL BREADTH IN THE THREE GROUPS

The different classes of nose width are given in the first column; in the successive column, left to right, the proportion of each racial group that has a nose of the class of width named in left hand column

Class mm	Whites percentage	Browns percentage	Blacks percentage
30–32	16.0	....	....
33–35	48.0	1.1	....
36–38	26.0	9.7	....
39–41	10.0	26.9	5.9
42–44	....	35.5	23.5
45–47	....	18.3	45.1
48–50	....	1.5	21.6
51–53	....	1.1	3.9
Mean and probable error	34.90 ± 0.24	42.61 ± 0.24	45.82 ± 0.26
Standard deviation and probable error	2.56 ± 0.17	3.44 ± 0.17	2.75 ± 0.18

have a nose which is intermediate in breadth (Fig. 2, c) and in later generations, indeed, in a mixed Negro population, we find a very great variability in nose breadth, as shown in Table A. An examination of this table shows that the variability of the browns, as the hybrids are called, is distinctly greater than that of the whites and blacks, as the coefficient of variability which is used as a measure of such variability shows. There are no broad-nosed whites and no narrow-nosed blacks, but the browns range all the way from narrow noses to broad noses.

Another distinguishing genetical trait is that of form of the hair, as measured by the diameter of the curl. This is, as every one knows, very small in the case of the Negroes (Fig. 2, a); very great in the case of the whites, a large proportion of whom, indeed, have no measurable curl in the hair. The browns are intermediate in respect to hair form (Fig. 5, d). The variability of this hair form, as measured by the coefficient of variation, is seen to be 50 per cent. greater in the blacks than in the whites.

Similarly, in skin color the offspring of two mulatto parents may run the whole gamut from a white skin to an ebony black, like that of the Negro ancestor. The range in variation of skin color in such hybrids is, indeed, very great.

We conclude, accordingly, that in human hybrids, as in other animal hybrids, variability of the hybrids is a widespread phenomenon, especially that those traits that are different in the parental stocks vary in the descendants. In those cases where such extraordinary variability is not found in the hybrids the conclusion is supported that the parental stocks were not themselves pure, or else that the trait depends upon a large number of genes, or that there has been selective mating, tending to eliminate variability.

We have studied about thirty physical traits in the three groups. In some of these the Negroes and whites differ so greatly that it is quite certain that distinct genes are involved. Thus the races differ in length of arm-span and leg (Fig. 6), which are both greater in the

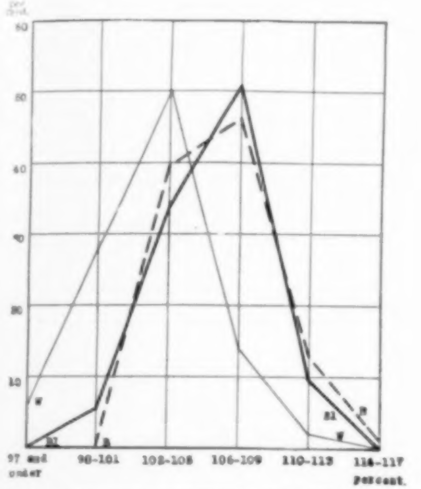


FIG. 6. GRAPHS SHOWING DISTRIBUTIONS OF SPAN ÷ STATURE FOR MALE WHITES (FINE LINE), BROWNS (BROKEN LINE) AND BLACKS (HEAVY, CONTINUOUS LINE). NOTE THE RELATIVELY SHORT ARMS OF THE WHITES. THE BROWN CURVE HAS A BROAD PEAK, COVERING BOTH PEAKS OF THE PURER RACES.

Negro than in the white. The breadth of the pelvis (Fig. 7) is much less in the Negro. The lower arm constitutes a relatively greater fraction of the entire arm in the Negro. The Negro's head is longer, but not broader or higher. The distance between the pupils is much greater than in the whites (Fig. 3, d). The feet and hands are longer in the blacks. The outer ear is not so long. There are fewer hairs developed on hand, arm and leg, and such as there are are short (Fig. 8). The internal impulses that direct development are very different in the two races.

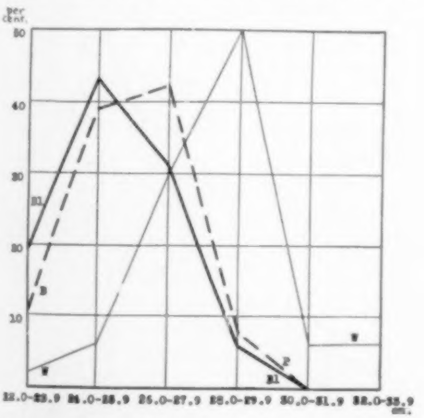


FIG. 7. GRAPHS SHOWING DISTRIBUTION OF INTERCRISTAL (PELVIC) BREADTH (IN CENTIMETERS) FOR MALE WHITES (FINE LINE), BROWNS (BROKEN LINE) AND BLACKS (HEAVY, CONTINUOUS LINE). NOTE THE RELATIVELY SMALL PELVIC BREADTH OF THE BLACKS. THE DISTRIBUTION IN CASE OF THE BROWNS FORMS A BROAD PEAK EXTENDING FROM THE PEAK OF THE BLACKS AND REACHING TOWARD THAT OF THE WHITES.

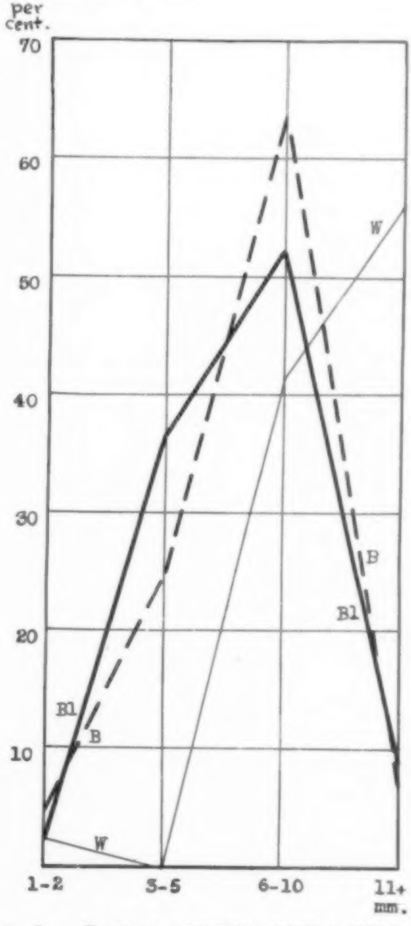


FIG. 8. GRAPHS SHOWING DISTRIBUTION OF AVERAGE LENGTHS OF HAIR ON ARMS IN DIFFERENT INDIVIDUALS OF THE 3 RACIAL GROUPS: WHITES (FINE LINE), BROWNS (BROKEN LINE) AND BLACKS (HEAVY, CONTINUOUS LINE). THE COMMONEST GRADE OF THE WHITES IS ONE ATTAINED BY FEW BLACKS OR BROWNS.

In the matter of hybrid vigor very little evidence was obtainable from the studies made in Jamaica. The most aberrant individual in size that we met was a huge woman over six feet tall. We could not be sure that she is a hybrid. This extreme case, however, was no doubt due to a pituitary disturbance, and pituitary disturbances may sometimes be due to a disharmony introduced by hybridization. On the average, however, the browns do not differ from the blacks in height and weight.

It is in the fields of the physiology and psychology that the relation of hybrids to parental stocks has the greatest social importance. In the matter of tooth decay, whose social importance is now becoming recognized on account of its relation to general health, we find a clear difference between the Negroes and the whites, in that the Negroes show a smaller amount of decay. The index of decay in the Negroes is 3.4 and in the whites 4. The browns show, indeed, a still slightly smaller average of defect, although the difference between the browns and blacks is less than the probable error. The condition in the browns is much more variable than in the blacks. The superiority of the browns is probably due to the inclusion of a considerable number of men from Mico College, young men who have been especially trained in the care of their bodies. Of the 21 per cent. of young brown males that showed no tooth decay about three quarters are from Mico College. Apart from such persons the distribution of tooth decay in browns is not very different from that of the whites.

Interesting differences between the blacks and the whites appear in their ability to make fine discriminations in the elements of musical capacity, as measured by the Seashore test. Thus the grades obtained in discrimination of pitch by the blacks are measured, on the average, by the score of 75, whereas the whites received the score of 71 and the browns the score of 77, being very close to that of the blacks. Indeed, nearly 30 per cent. of the browns received below 50 per cent. in pitch discrimination, as opposed to only 10 per cent. of the whites and 19 per cent. of the blacks. We see, then, that the blacks discriminate pitch better than the whites and that the browns are very variable, and a larger proportion of them than the whites, even, are unable to make any but the crudest discriminations.

In the matter of rhythm, also, the blacks are far superior to the whites, scoring an average of 86 to the whites' 78. The browns show a great range of scoring from 50 to 100 (Fig. 9). There is a larger percentage of the browns in the highest group than in the whites, but, conversely, in the lowest groups there are found many more browns than blacks, so that the brown group is characterized by including many persons who show very poor, as well as many who

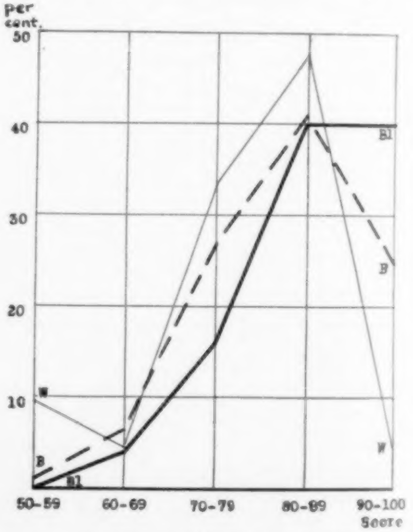


FIG. 9. GRAPHS SHOWING DISTRIBUTION OF SCORES OR GRADES OBTAINED IN THE SEASHORE TEST FOR RHYTHM IN MUSIC, IN 3 RACIAL GROUPS: WHITES (FINE LINE), BROWNS (BROKEN LINE) AND BLACKS (HEAVY, CONTINUOUS LINE). THE GREAT PREDOMINANCE OF BLACKS IN THE HIGH SCORES, AND THE VARIABILITY OF WHITES AND BROWNS ARE WELL SHOWN.

show very good appreciation of differences in rhythm.

For more strictly intellectual tests certain performance operations were carried out. Thus in the cube imitation test in which the subject has to reproduce a certain more or less complicated sequence of movements of the examiner the blacks get a score of $4\frac{1}{2}$, as contrasted with that of $6\frac{1}{2}$ obtained by the whites. The whites do, therefore, nearly 50 per cent. more of the test correctly than do the blacks. The browns are nearly intermediate in their efficiency in this test, although they lie somewhat closer to the blacks than to the whites.

In the matter of drawing a man, without "copy," the whites did best, while the blacks were not inferior to the browns (Fig. 10).

Another test employed was that of putting together six pieces of wood on which were drawn the parts of a man. These were to be placed so as to reconstruct the image of a man. The blacks took longer to make the reconstruction than the whites. Thus, on the average, blacks took forty-three seconds, as contrasted with twenty-six seconds required by the whites. The browns are intermediate but much closer to the blacks than to the whites in this capacity, and, as measured by the standard deviation, their scores were the most variable. But more of the browns failed to finish the test (over ninety seconds) than of the blacks (Fig. 11).

Another test applied was the so-called Knox moron test, consisting of a board with a hole into which were to be placed blocks of different form so as completely to fill the hole. The blacks, on the average, took 119 seconds to perform this test; the whites 87 seconds and the browns 113 seconds. Thus, again, the browns were intermediate and closer to the blacks than to the whites. This is a test which involves a good deal of imagery, some foresight, planning and ability to make use of past experiences

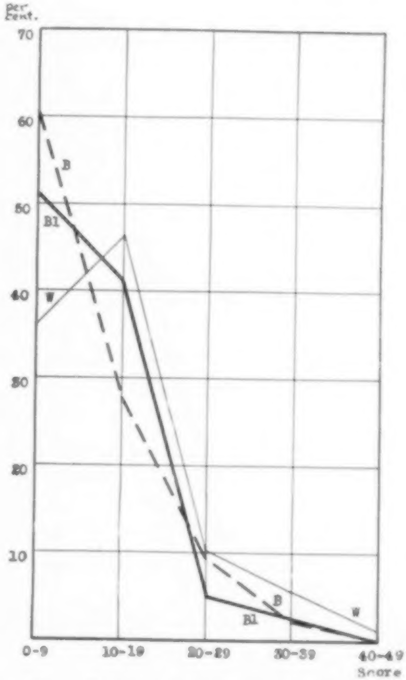


FIG. 10. GRAPHS SHOWING DISTRIBUTION OF SCORES OR GRADES OBTAINED IN THE DRAWING OF A MAN BY THE 3 RACIAL GROUPS, MALES AND FEMALES COMBINED: WHITES (FINE LINE), BROWNS (BROKEN LINE) AND BLACKS (CONTINUOUS, HEAVY LINE). THE WHITES HAVE FEWEST FAILURES (0–9) AND SHOW A LARGER PERCENTAGE IN ALL THE HIGHER SCORES THAN ANY OTHER GROUP. NOTE THE LARGE PROPORTION OF FAILURES AMONG THE BROWNS.

and this group of traits seemed to inhere in the whites of Jamaica more than in the blacks.

The Army Alpha tests of intelligence were used with some interesting results. Thus the second test is that of ability to make simple arithmetical computations. Simple questions were asked, like this: How many are 60 guns and 5 guns? More complicated questions were of this nature. A rectangular bin holds 200 cubic feet of lime. If the bin is 6′ long and 10′ wide, how deep is it? In this arithmetical test the adult blacks did better than the whites, scoring, on the average, 10 correct out of a total of 20, whereas the whites scored only $7\frac{1}{2}$. The

browns scored 8.4 and thus were intermediate in their performance between the blacks and whites.

Another test in the Army Alpha is No. 3—a test of common sense. The question is asked, for example, "Why do we use stoves?" and suggested answers are "because they look well"; "they keep us warm"; "they are black." The subject is to check the appropriate answer. Now in this exercise of common sense the blacks were clearly inferior to the whites, since they scored less than 6 right out of 16, while the whites averaged 8½ right. The browns, on the other hand, scored only about 5 correct, being inferior in this respect to either the Negroes or the whites. A summary of the results of the Army Alpha tests is shown in Table B.

TABLE B

SUMMARY OF MEAN SCORES OBTAINED IN THE EIGHT ARMY ALPHA TESTS

	I	II	III	IV	V	VI	VII	VIII	Avg.
Black	*5.9*	*10.0*	5.9	15.8	8.8	*7.2*	*13.9*	9.6	9.64
Brown	5.1	8.4	5.2	12.7	6.4	5.6	10.8	9.4	*7.95*
White	4.9	7.5	*8.5*	*20.3*	*11.4*	6.8	10.2	*12.2*	*10.23*

This reveals the fact that, considering all tests together, the whites do better than the blacks, on the average, despite the fact that in respect to some of the tests the blacks are slightly superior to the whites. The browns, on the average, are inferior to either the blacks or whites.

If we consider the relative standing of the three groups at different ages we reach a somewhat surprising result, namely, that the children of ten to thirteen years do better in the brown group than in either black or white. The children of thirteen to sixteen years also are superior in the browns, but in the adults, as stated, the browns are clearly inferior to either of the parental stocks. Apparently the browns mature earlier (possibly an evidence of hybrid vigor), but their development stops earlier.

This inefficiency of the adult browns depends upon the presence of an excessively large number of persons in that group who are incapable of making any progress at all with the task before them. We have seen this in the cube imitation test, where 7 per cent. of the browns get the poorest score, as contrasted with 3 per cent. of the blacks and none of the whites. We have seen it again in the time required to put together the manikins in which 5 per cent. of the browns surpassed the limit of one and a half minutes; only 3 per cent. of the blacks and 2 per cent. of the whites (Fig. 11). Repeatedly the scores of the browns are characterized by this phenomenon. An exceptional number show complete failures; a fairly large proportion of persons are as competent in the task as the whites. The reason why the browns are intermediate between the blacks and the whites, or below either, is because of this large burden of ineffective persons who seem to be muddleheaded or incapable of collecting themselves to do the task in hand. One gets the impression that the blacks may have on the average the inferior capacity but are able to use what they have. The browns, as a whole, have a superior capacity to the blacks, but there is a much larger proportion of them who through becoming rattled or through general muddleness are unable to make any score; while, on the other hand, a large number do brilliant work.

This result serves to explain a difference of point of view of persons who have written about mulattoes. It is insisted by some that mulattoes are superior to the blacks in mental capacity. Others stress their unreliability, untrustworthiness, general inefficiency. The group who stress their superiority refer to such eminent citizens as Booker T.

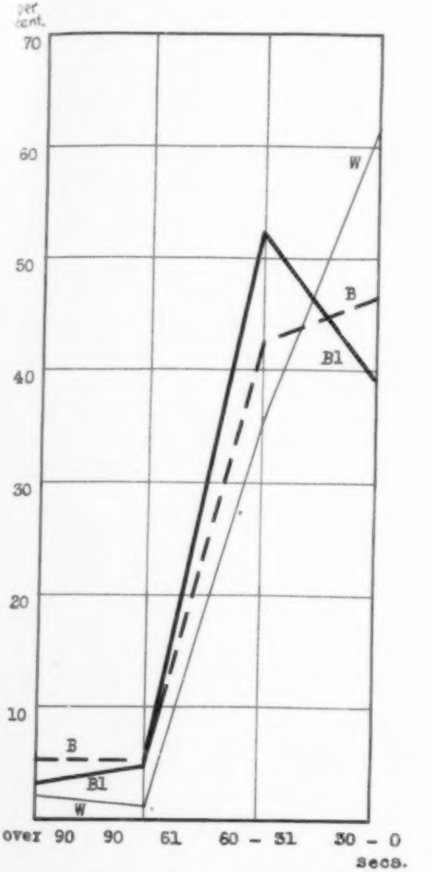


FIG. 11. GRAPH SHOWING DISTRIBUTION OF TIMES REQUIRED TO PUT TOGETHER THE PARTS OF THE MANIKIN BY 3 RACIAL GROUPS, MALES AND FEMALES COMBINED: WHITE (FINE LINE), BROWN (BROKEN LINE), BLACK (CONTINUOUS, HEAVY LINE). NOTE THAT THE WHITES DO BEST IN THE SHORT-TIME CATEGORIES (0–30 SECS.). A LARGER PROPORTION OF THE BROWNS (B) FAIL TO PUT THE MANIKIN TOGETHER (OVER 90 SECS.) THAN OF THE BLACKS (B1).

Washington, Frederick Douglass, Dr. DuBois. Those who stress their inefficiency see the other end of the series—the people who, apparently through mental conflicts, are extraordinarily ineffective. This, then, is one of the results of hybridization between whites and Negroes—the production of an excessive number of ineffective, because disharmoniously put together, people. A list of the traits has been prepared in which the browns are clearly inferior, on the average, to blacks and whites. This includes the ability to draw a man, without a model to copy. Such a task involves imagery and organization in which the browns seem, on the average, to be inferior. Again, they are inferior in the form substitution test in which one writes an appropriate figure in each of some five or six different form symbols many times repeated. The browns make more errors in assigning the proper figures to the symbols than do the blacks, although, on the average, they attempt rather more of the substitutions. In four of the eight Army Alpha tests the browns seem to be inferior to both the blacks and whites. These are all important tests of mentality and lead to the conclusion that, on the average, the browns are frequently inferior in mental tests, while they show more extremes of excellent and poor performance than the other groups. The only mental tests in which the browns are superior to either blacks and whites are certain exercises done by children between the ages of ten to sixteen years. This fact again illustrates the precocious development of mentality in the brown child. Also, the adult browns were superior in repeating a given series of figures.

The application of the results of the study of Negroes, whites and hybrids between them in Jamaica leads to the conclusion that physically there is little to choose between the three groups, although, on the whole, the Negro makes the better animal and, especially, is provided with better sense organs. The browns show much greater variability and, indeed, are put together differently from the average whites and blacks. Thus, whereas the whites are characterized by relatively short legs and long body and the blacks by relatively long legs and short body, some of the mulattoes have an unexpected combination of

long legs and long body and others of short legs and short body. Also, while there is a high degree of correlation between leg length and arm length, some of the hybrids are characterized by the long legs of the Negro and the short arms of the white, which would put them at a disadvantage in picking up things from the ground.

But in regard to intellectual traits the conclusions are different. The browns show great variability in performance. They comprise an exceptionally large number of persons who are poorer than the poorest of the Negroes or the poorest of the whites. On the other hand, they show some individuals of a high intellectual quality. The average of the performance of the browns is generally somewhat better than that of the Negroes. It is, however, this burden of ineffectiveness which is the heavy price that is paid for hybridization. A population of hybrids will be a population carrying an excessively large number of intellectually incompetent persons. On the other hand, a population composed of hybrids between whites and Negroes will contain persons better endowed in appreciation of music and in simple arithmetical or mental computations, as well as more resistant to certain groups of diseases, than a pure white population. If only society had the force to eliminate the lower half of a hybrid population, then the remaining upper half of the hybrid population might be a clear advantage to the population as a whole, at least so far as physical and sensory accomplishments go.

The person who seeks to secure the racial improvement of any species has only two courses open to him: Either to await new mutations in the race which he wishes to improve, or else to cross it with some other race that already has the quality he desires.

Thus the English race, which is poorly endowed with musical capacity, could get that capacity by mingling with the Negro.

The difficulty in waiting for the desired mutation to arise in the race is that it is a slow method. The method of hybridization has the difficulty that it introduces other, undesired traits into the complex. Of course, by controlled selective breeding the undesired traits can be bred out, while the desired traits are retained.

But we have no such control of human matings as is demanded if success is to follow the method of improvement by race crossing. It seems hardly applicable to mankind.

Moreover, quality of performance is not the only test of ability to play a part in society. There exists in mankind a strong instinct for homogeneity. Even children tend to mock at the cripple or deformed person. A homogeneous group of white people will always be led by its instincts to segregate itself from Negroes, Chinese and other groups that are morphologically dissimilar from themselves. We should consider the psychological, instinctive basis of this feeling. It is not sufficient merely to denounce it. It probably has a deep biological meaning and so long as it exists, so long we should be led to follow it as a guide if we are to seek to establish a commonwealth characterized by peace and unity of ideals.

THE GOBIES OF THE GULF OF GUINEA

By Professor A. S. PEARSE
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ALONG the coast of Nigeria ramparts of land cut off long strips of water from the ocean. These lagoons receive fresh water from the mighty Niger and many smaller streams. They parallel the coast and serve as safe highways for the patch-sailed dug-out canoes of the native fishermen and traders. The water is so shallow that when the wind fails, boats are easily poled about. Mangroves flourish in such situations, and there are hundreds of miles of these fantastic plants. Among their branches are strange birds and agile monkeys; on their roots are crabs and — most wonderful climbing fishes! I write of the last, which the British in Nigeria call mud fishes.

If one takes a lazy canoe journey through the estuary of a small stream, he sees mud fishes everywhere. They skip over the flats and hide in the grass as the canoe approaches. They leap from a near root, take a few skips on the surface of the water and climb quickly up a far root. From this point of vantage they roll their eyes at strange intruders. If cornered, a mud fish may, with apparent reluctance, take to the open water and swim laboriously, with its nose and eyes above the surface. As a last resort, it may even dive some distance under the water.

Occasionally a mud fish may sit stolidly on his root and allow a boat to approach quite closely. The canoe bumps his root, and still he sits motionless. I stretch out my hand, thinking perhaps he is asleep, but when the hand is six inches away he gives a flip of his tail and skips over the water into an inaccessible tangle of roots.

A naturalist who sees a mud fish is of course filled with a desire to collect the beast and take its picture. My native "boy," Rufus, captured several specimens by chasing them into crab holes and reaching down into the muck with his hand. After hours of patient, stealthy effort, we took pictures, most of them worthless, but a few fairly good.

Mr. J. T. Nichols has been kind enough to identify the Nigerian mud fish as *Periophthalmus koelreuteri*. Among climbing fishes this is a rather large species, as it often attains a length of more than six inches. It is one of the gobies, which are a widely distributed family. In Europe gobies are ordinary stream fishes. In Hawaii there is a species which adheres to rocks in swift mountain streams with a sucker which is formed by a pair of fins. Along the shores of the Pacific Islands certain species are beach skippers. A large skipper hops about on the mud flats at Guam and dodges into crab holes when pursued. In the Philippines small gobies tug worms out of the mud in the intertidal zone; for all the world like robins extracting earthworms from a lawn. About the mouths of Siamese rivers there is a mud fish which makes burrows that extend down to a depth of three or four feet.

When one sits for hours on the hard bottom of a dug-out canoe, with nothing to do except watch for mud fishes and occasional monkeys, at the same time keeping a subconscious vigil over his back and the under sides of his legs for tse-tse flies, he has time for thought. And he thinks—even in sultry, somnolent Nigeria. I thought of the ocean as the first home of life and of the gradual invasion through the ages of land and freshwater habitats. This is perhaps

THE MUD FISH, *PERIOPHTHALMUS KOELREUTERI*

one of the most exciting chapters in the book of natural history. Many groups of animals have had abundant opportunities to attain the ability to breathe air and thus take up life on land, but only three have met with any degree of success—snails, arthropods (crabs, insects, spiders, etc.), and vertebrates.

Land animals have the advantage of living in the atmosphere which, as it is less dense than water, permits more rapid movement. Speed is also favored by the fact that more oxygen, which is through oxidation the basis of all animal activity, is more abundant in air than in water. The disadvantages that accompany land life are the seasonal fluctuations in available food, the rapid and extensive changes in temperature, and the danger of loss of water from the bodies of animals, by drying out. It is on the whole true that the quicker land animals which live in more variable environment have in many instances a higher degree of psychological development. The opportunity to move fast has been associated with the development of sense organs which could perceive objects and conditions more accurately at a distance. It is much more necessary for an automobile which travels at sixty miles per hour to have an unobstructed view and accurate control than it is for a canal boat which loafs along at three miles per hour. The variable environment that land animals entered when they left the ocean put a premium on astuteness. An animal that had a harder struggle to live was obliged to have more expedients for meeting unfavorable changes in its environment. Through the ages, land animals have established

MANGROVES

types which are wiser than their more primitive relatives in water habitats. The reward for struggling to land has been greater wisdom, with the ability to live faster and, in a sense, on a higher plane from day to day.

In their past migration from sea to land animals have taken perhaps three or four routes. Certain land crabs and some other crustaceans probably went directly to land through the intertidal zone. At the present time there are species which show varying degrees of adjustment to land life. Fiddler crabs carry sea water in their gill chambers and spend long periods out of water. The ghost crabs do not carry sea water with them, but visit the ocean frequently to wet their gills. The cocoanut crab has rudimentary gills and lungs which have developed as pouches from the gill chambers. It visits the ocean only once a year, when it returns to its ancestral home and leaves its offspring to spend a few days as water animals. Some sand-hoppers live on land but can not endure freshwater and quickly die in it.

The lung fishes which live to-day, and probably the ancestors of modern land vertebrates, are believed to have been forced to take up land life by aridity. They first invaded freshwater and became adapted to swampy situations. Then during long dry periods, they gradually became adjusted to land. Barrell says lung breathing is "an adaption which has been forced repeatedly on fishes by the recurrence of an unfavorable environment rather than one assumed within a constant environment because of inherent advantages." It was probably not so much the lure of abundant oxygen as the drying up of aquatic habitats which caused vertebrates to take up land life.

Another route from sea to land appears to have been through initial adjustment to swamp or marsh life and

RESTING ON A MANGROVE ROOT

TWO GOBIES CLIMBING MANGROVE ROOTS

later adjustment to land. In this case the need of oxygen doubtless led aquatic animals to invade the atmosphere. In shallow swamps the decay of dead plants and animals with the activities of living

SEVEN GOBIES WALKING DOWN THE BEACH

IN THE MANGROVES

organisms may use up all the oxygen, so that none is present in the water. Swamp snails are generally pulmonates (air-breathing) and continually come to the surface. Some even deposit their eggs on twigs above the water. Mangroves grow on bottoms of soft, stinking muck. There is a lack of oxygen and their underground roots send up breathing rootlets which obtain oxygen from the air. In such situations crabs, snails and fishes climb up on the mangrove

roots and the fishes show some reluctance to enter the water, which may contain a lurking crocodile. In the moist Nigerian climate a mud fish appears to suffer no injury if kept overnight in a bucket without water. Some of the beach skippers of the Malayan region drown in a couple of hours if kept under water. A species of "climbing perch" in the Philippines may live as long as six days out of water.

The mud fishes along the Gulf of Guinea are, like many of their relatives in other parts of the earth, making a drive toward land. They have attained some of the acuity of vision and quickness of motion that characterizes land animals. They have pouches developed from their gill cavities which serve as lungs. Perhaps in a million or a billion years they may become proper land animals.

A GLIMPSE OF AUSTRALIA

By Professor ANDREW C. LAWSON

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AUSTRALIA is slightly larger than the United States, but it has only about 5 per cent. of our population. It is a pastoral and agricultural country, the early development of which, like that of California, was stimulated by a gold rush in the middle of the nineteenth century. Since the exhaustion of its placers it has had some great mining camps, such as Mount Morgan, Broken Hill, Kalgoorlie and Cloncurry, the spectacular production of which has done much to make Australia famous. But to-day the metal mining industry is in a decline. Many of the great mines are either exhausted, or, having been gutted of their bonanza ore, are no longer profitable at present wage costs, and no new discoveries of rich ore bodies are being made. Whatever discoveries may be made in the future, their exploitation will lead to the exhaustion exemplified in our own Comstock, Goldfield and Cripple Creek. Their influence on the development of Australia, though surely beneficent, will be evanescent. When metal mining has become relatively unimportant and even negligible, the pastoral and agricultural resources of the land will remain and will continue to yield up their wealth to the people.

Coal is, however, abundant in the more populous regions of the continent, and there is sufficient iron for domestic needs. Up to the end of the nineteenth century nearly all manufactured goods used by the Australians were imported, but during the first quarter of the twentieth century there has been a steady growth of the manufacturing industry, representing the efforts of a self-contained and peculiarly isolated country to supply its own needs. There is little doubt but that these efforts will be extended, and that the general manufacture of goods for home consumption will gradually be developed.

The chief commodities which Australia has to balance her long and costly list of imports are wool and wheat. The breeding of sheep to produce heavy yields of fine merino wool, and the pasturing of these on a vast scale has been Australia's great achievement and her most notable contribution to the world's economy. The acreage devoted to wheat is steadily increasing, and, notwithstanding the somewhat critical climatic conditions which prevail in the new territories being brought under the plow, it is probable that Australia will grow in importance as one of the world's granaries. In recent years there has been a large increase, also, of exports of dairy products.

A traveler's tale concerning this vast, thinly populated but vigorous country on the other side of the world is of course not to be trusted. Nevertheless, at the risk of confirming such skepticism, I propose to narrate some things concerning Australia which came to my attention during a recent journey across that continent.

I shall first sketch briefly[1] the physiography of the Australian continent, its relief, geological structure and climate, so that my readers may have a proper appreciation of the lure of the land in

[1] Most of the facts here recited are well known to Australian geologists and geographers, and this paper does not profess to be an original contribution to our knowledge of Australia but only a summary review of matters that should be better known.

A SKETCH MAP OF AUSTRALIA

which has been eventually founded a strong Anglo-Saxon commonwealth in the southern hemisphere, and know something of the difficulties that have been overcome, and have yet to be overcome, in this remarkable extension of the English-speaking people.

Compared with other continents the relief of Australia is very subdued. It may be regarded as a tableland which has been elevated somewhat at its eastern and southeastern margin. This marginal highland belt is commonly referred to as the Eastern Cordillera; and there are, indeed, some mountains in it toward the south which have an Alpine character. Of these Mount Kosciusko is the most notable, having an elevation of 7,300 feet near the boundary between Victoria and New South Wales. But by far the greater portion of the Eastern Cordillera is a dissected plateau, the residual mesas and ridges of which do not usually exceed four thousand feet in New South Wales, and half this in Queensland. The trend of this elevated belt is curved, with a pronounced convexity to the Pacific; and this convexity of the axis of uplift has determined the contour of the eastern coast of the continent.

The descent to the sea on the east side of the uplift is abrupt, while on the west side, in the concavity of the curve, there is a very gentle slope to the lower plains of central Australia. The divide for the major drainage of the continent is thus at its eastern side. The streams to the east are short and in their upper reaches flow in steep walled canyons; but as they leave these near the coast they pass into broad pleasant valleys. The intricate and deep dissection of this uplifted margin of the continent has given rise to an extremely rugged but picturesque country; so rugged in

A RAILWAY CUT AT ZANTHUS, ON THE TRANSCONTINENTAL RAILWAY, SHOWING THE CONCRETIONARY CHARACTER OF THE SUB-SOIL UNDER THE DRY BUT WOODED CENTRAL PLAINS

New South Wales as to constitute a serious barrier to communication and transportation between the coast and the interior; so picturesque that it has become famous and has many colonies of summer homes on its commanding summits.

On the west of the divide are the long rivers of the continent, and these drain three hydrographic basins. The largest and most important is that to the south traversed by the Murray and its tributary, the Darling, flowing into the Southern Ocean about fifty miles from Adelaide. To the north, the hydrographic basin of the Flinders River and its tributaries drains the western slope to the Gulf of Carpentaria. Between these two lies a vast interior basin with no outlet to the sea. The chief rivers flowing from the divide into this basin are the Diamantina and Barcoo. Their waters are lost in Lake Eyre, a great desert evaporating pan partly occupied by saline residues, lying below sea level.

West of the Eastern Cordillera there are only two other portions of the continent which attain an altitude of over two thousand feet. One of these comprises the Mount Lofty, Flinders and other ranges in South Australia, extending from the southern coast near Adelaide with a meridional trend to the vicinity of Lake Eyre. The ridges which comprise this highland tract are paralleled by longitudinal valleys of depression, in two of which lie Spencer Gulf, Torrens Lake and the Gulf of St. Vincent. The highest point of the South Australian highlands is Mount Brown, which has an elevation of 3,100 feet. The other high region is in the center of the continent under the Tropic of Capricorn. Here a very considerable area, including the MacDonnell Ranges, is enclosed by the two-thousand-foot contour. All the rest of Australia, excepting the island of Tasmania, is a vast plain. Of this plain the eastern third, comprising the middle or closed hydro-

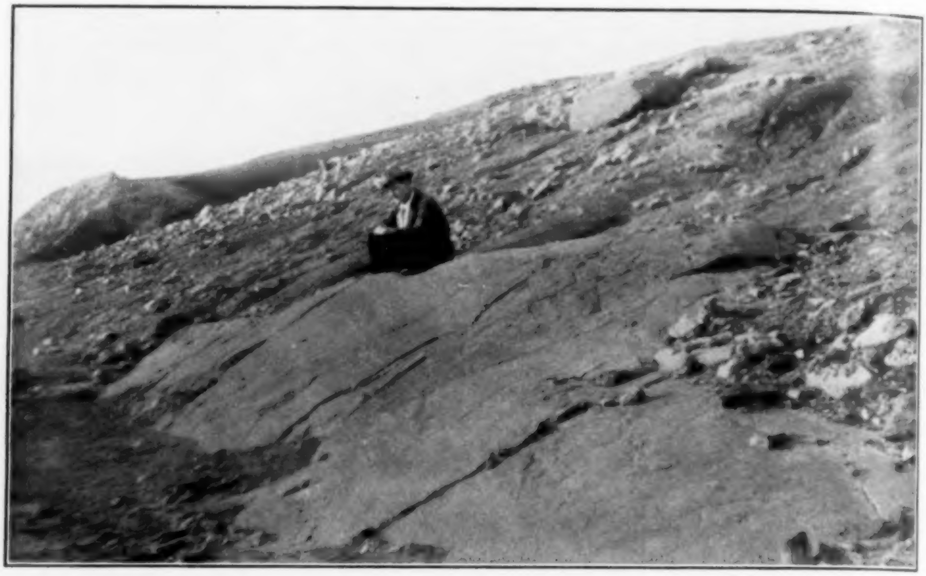
graphic basin and large parts of the southern and northern basins, is known as the Great Artesian Basin. It lies below the one-thousand-foot contour, and perhaps half of it is below five hundred feet. To the north it passes into the lowlands which encircle the Gulf of Carpentaria, which is itself a very shallow sea. The Great Artesian Basin is underlain by undisturbed Mesozoic strata which afford storage for large quantities of underground water, and this has become an important factor in the settlement and utilization of this vast arid tract.

The western two thirds of the continental plain has for the most part an altitude of from one thousand to one thousand five hundred feet. On the south it forms the coast of the Great Australian Bight, where it presents an unbroken sea-cliff for many hundreds of miles to the Southern Ocean. On the west it breaks away with a steep front to a low, narrow, coastal plain at the shores of the Indian Ocean. On the northwest side of the continent, from about latitude 28° South to the Arafura Sea, the plain drops more irregularly but gently to the coastal lowlands. The contours of the land are deeply indented, the profiles are flat and there are many embayments of the coast. The rivers draining into these embayments are almost limited to the coastal lowlands, their headwaters not reaching far into the interior continental plain. Compared with the drainage from the western flank of the Eastern Cordillera these rivers are therefore short, and appear as unimportant features on the general map of Australia. The general facts as to relief and drainage may be pictured if we think of the Appalachian Mountains as the only watershed in the United States. From the eastern flank of this divide imagine a group of streams flowing to the Great Lakes, another group to the Gulf of Mexico, and the Ohio in between flowing westward to an evaporating basin in Oklahoma. Think of all the rest of the country between Canada and Mexico as a dry, monotonous plain, devoid of rivers, extending almost to the Pacific Coast, say as far as the Sierra Nevada and the Cascades. The hills known as the MacDonnell ranges do, it is true, rise above the general level, but they only serve to accentuate the general appalling flatness of the continent. Where the transcontinental railway traverses this plain there is one portion of the track with negligible grades which is as straight as a stretched string for 330 miles without a bridge.

The explanation of these remarkable features of Australian physiography is of course to be found in the geological history of the continent. The greater

THE NULLARBOR PLAIN

THE TREELESS WASTE THROUGH WHICH THE TRANSCONTINENTAL RAILWAY RUNS FOR HUNDREDS OF MILES WITHOUT A CURVE OR A BRIDGE. THE PLAIN IS UNDERLAIN BY LIMESTONE CONTAINING MANY SINK HOLES AND UNDERGROUND CHANNELS INTO WHICH THE SCANT RAINS PROMPTLY FLOW, SO THAT THERE ARE NO WATER COURSES ON THE SURFACE



GLACIATED PAVEMENT DUE TO PERMIAN GLACIATION

HALLETT'S COVE, NEAR ADELAIDE. THE GRADUAL STRIPPING OF THE TILLITE BY THE WEATHER HAS EXPOSED AS FINE A *roche moutonnée* SURFACE, POLISHED AND STRIATED, AS COULD BE FOUND IN THE GLACIATED REGIONS OF CANADA OR THE HIGH SIERRA

part of the surface appears to have been reduced in Precambrian time to a peneplain which has persisted in the geomorphy ever since. In Cambrian time geosynclinal basins of sedimentation were developed on the southern and northwestern margins of this peneplain, as its limits are known to-day. In the southern basin the normal process of marine sedimentation was interrupted by a continental glaciation, the ice flowing toward the equator from a land mass now vanished which was located in the region of the Great Australian Bight. On its retreat this ice sheet left extensive moraines, about one thousand feet thick, which are now exposed in the Mount Lofty Range near Adelaide as tillite. Marine sedimentation was then resumed and the tillite was deeply buried in the geosyncline by the later Cambrian deposits, the total thickness of the Cambrian being about ten thousand feet. The southern basin has suffered acute deformation, but the date of this diastrophism is uncertain. The Cambrian basin on the northwest side of the continent has been much less deformed. The sedimentary beds are several thousand feet thick and rest on lavas which are probably also of Cambrian age.

On the eastern side of the early continent, in the region of the present Eastern Cordillera, there existed a persistent, or recurrent, geosyncline throughout Paleozoic time, certainly from the end of the Cambrian on, and possibly also including the Cambrian. In this trough there accumulated vast thicknesses of Ordovician, Silurian, Devonian, Carboniferous and Permian strata. The formations in this trough suffered deformation by folding, locally at the end of the Ordovician, generally at the end of the Silurian and generally at the end of the Carboniferous. These diastrophic movements gave the Eastern Cordillera their mountain structure, but the high ranges, which were also an expression of these movements, were worn down to

low relief before the advent of Permian time; since there are widespread Permian formations over the region which exhibit little or no folding. The maxima for the thicknesses of the several divisions of the Paleozoic in eastern Australia as given by David, are: Ordovician, 9,000 feet; Silurian, 4,000 feet; Devonian, 33,000 feet (including volcanics); Carboniferous, 20,000 feet, and Permian, 15,000 feet (including volcanics). The source of these vast volumes of sediment is an interesting question. It appears improbable that they came from the west, since the western part of the continent was a stable region of low relief, incapable of supplying sediments in large quantities. This makes it probable that the Paleozoic sediments were derived from a land mass which lay to the east of the present eastern coast of Australia. The core of the Fiji Islands, New Caledonia and perhaps New Zealand may be remnants of this almost vanished continental area. On this supposition of an eastern derivation of the Paleozoic sediments of Victoria, New South Wales and Queensland, the Eastern Cordillera becomes analogous to the Appalachian mountains, the Paleozoic sediments of which were derived from the land mass called Appalachia, now almost vanished beneath the waters of the Atlantic. And the analogy persists in the relation of the antecedent geosyncline to the Australian continent, and in the collapse of that trough toward the end of the Paleozoic, when it became overladen with sediments. Still another point of analogy is the fact that the Eastern Cordillera is in no sense the ranges which were formed at the time of the collapse, but are due to a more recent uplift of the region after those ranges had been reduced by erosion to low relief, just as the Appalachians are due to the post-Cretaceous uplift of the peneplain to which the ranges, formed at the time of the Appalachian Revolution, had been reduced.

The Permian Period which followed after an interval of partial peneplanation was inaugurated by outpourings of volcanic lavas and by glacial conditions. A vast continental ice sheet overrode the greater part of the continent, perhaps more than once, advancing from the region of the present Great Australian Bight, which must then have been a land area. On its retreat, or retreats, this ice left morainic sheets which now appear as tillite at many widely spaced localities in the basal division of the Permian. And these tillites may be seen to rest upon scored and polished *roches moutonnées* pavements as perfect as any due to the Pleistocene glaciation of North America, or to the Alpine glaciation of the Sierra Nevada. This widespread glaciation of Australia was contemporaneous with a similar glaciation of South Africa, South America and India and was a manifestation of glacial climate far more extensive than that of the Pleistocene. It is remarkable that, though the evidence of this Permian glaciation is abundant in the several continents, it is all found in regions much closer to the equator than to the poles. The relatively small extent of the land areas in the southern hemisphere may explain this fact south of the equator; but in the northern hemisphere Permian rocks are widely distributed and are well known, yet the evidence of Permian glaciation is scant and such as has been found is nearer the equator than the North Pole. Immediately after this glacial epoch conditions prevailed which were favorable to the accumulation of coal, and the principal coal measures of Australia are in the upper division of the Permian.

In early Mesozoic time certain parts of the present Eastern Cordillera were the site of the accumulation of freshwater beds, chiefly fluviatile, as shown by the common crossbedding of the sandstones, but in part lacustral, as indicated by shales, and comprising occa-

PERMIAN TILLITE RESTING ON GLACIATED PAVEMENT OF CAMBRIAN QUARTZITE
HALLETT'S COVE, NEAR ADELAIDE

sional coal seams due to local swamp conditions. These Triassic formations, to a maximum thickness of about three thousand feet, succeed the Permian without discordance, and as in many other parts of the world are significant of the persistence of the continental conditions of the Permian into the early Mesozoic. These formations considered as a whole represent the building up of a great delta, or series of deltas, by rivers commonly and characteristically laden with coarse sand, which doubtless was the product of the erosion of the high parts of the primitive Cordillera. The subaqueous portion of the delta is unknown. It either extends below the later Mesozoic rocks of the Great Artesian Basin or is now beneath the Pacific and, therefore, was deposited beneath the Pacific. If the second of these alternatives be correct then the eastward extension of the continent, from which the Paleozoic sediments were derived, had, in large measure at least, been engulfed not later than the beginning of the Mesozoic.

With the progress of Mesozoic time, the area of depression, and therefore of sedimentation, shifted westward, and an extensive formation of fresh-water beds accumulated in the region of the present Great Artesian Basin. These are chiefly sandstones with occasional coal seams, and doubtless also represent the flood-plain deltaic deposits in a subsiding basin. The rise of the flood-plain by deposition was sufficiently rapid to keep it above sea-level throughout Jurassic time, notwithstanding the sinking of the floor of the basin. The thickness of the beds ranges from a few hundred feet to three thousand feet, and the maximum figure is the probable measure of the amount of depression.

In Cretaceous time, whether by an acceleration of the rate of sinking, or by a decrease in the sedimentary upbuilding of the flood plain, or by a rise of the surface of the ocean, the salt water invaded the basin and a broad epicontinental sea was formed, the transgression coming from the north in the region of

the present Gulf of Carpentaria. At the same time there was a similar transgression of the south coast from the Great Australian Bight. At the maximum of this Cretaceous inundation the southern sea was probably confluent with the northern, so that Australia was divided into two islands. The strata laid down in the northern basin have not yet, however, been traced in actual continuity with those deposited in the southern basin, and there may have been a narrow isthmus connecting the two insular masses.

This epicontinental sea, having an area of nearly half of Australia, filled up with Cretaceous sediments to a maximum thickness of two thousand feet, and when the basin was full the streams from the surrounding country added still other deposits of fresh-water sand to a thickness of a few hundred feet. The withdrawal of the marine waters left a low-lying arid plain which persists to this day, but slightly modified by the dissection and partial removal of the upper fresh-water sands. The partial submergence of the Australian continent by the Cretaceous sea was synchronous with a similar transgression of that sea over the greater part of North America and Europe, as well as a notable rise of the strand all around the continent of Africa. Such a widespread transgression of all the lands of the earth can only be explained as due to: (1) a universal depression of land surfaces relatively to sea-level, or, (2) a universal rise of the sea-level, or (3) a combination of depression of continents with rise of sea-level. The universality of the Cretaceous transgression implies the operation of a general cause; and whichever one of the three explanations may be considered the more probable, the fundamental cause is still a geological mystery.

The absence of formations which can be referred positively to the Eocene is an interesting feature of the geology of Australia. After the filling of the Cretaceous epicontinental sea with sediment the surface of the continent was slightly elevated so as to exclude the sea of Eocene time, and some of the Cretaceous beds were removed by erosion; but in later Tertiary time it was again rela-

PERMIAN TILLITE, AT SEAHAM, N. S. W.

CONTORTED VARVED SHALES OF PERMIAN TILLITE, AT SEAHAM, N. S. W.

THE DEFORMATION OF THE BEDS IS DUE TO THE PUSH OF THE GLACIER WHEN THE DEPOSITS WERE STILL PLASTIC

tively depressed so as to permit of a marine transgression, particularly from the south. Marine beds of Miocene age rest on the Cretaceous in a large lunate area north of the Great Bight, and these attain locally a thickness of one thousand feet. In the south central part of the continent, the dry plains crossed by the transcontinental railway represent the uplifted Tertiary sea-floor, which has been preserved in an almost wholly undissected condition owing to the absence of running water. The scant rains sink immediately into the porous rocks of the terrain and drain to the Southern sea by underground flow. There are no water courses at the surface for hundreds of miles.

In the region of rifts and graben near Adelaide marine Pliocene beds were deposited in local basins to a maximum thickness of about one thousand feet, as shown by borings. On the whole the area which was submerged in Tertiary time and received thereby a deposit of marine sediments was very limited. But this defect in Tertiary sedimentary strata was compensated for by the general activity of volcanoes. At various times throughout the Tertiary there were extensive extrusions of lava in the eastern and southeastern part of the continent. In this period also Tasmania became separated from the mainland by a slight submergence of the preexistent isthmus. At the end of the Tertiary an elevatory movement was inaugurated along the eastern margin of the continent, and the uplift, continuing down to the present, has given rise to the warped plateau, which in its present state of dissection is known as the Eastern Cordillera.

Although Australia was heavily and extensively glaciated in the Cambrian and Permian glacial periods, it was scarcely affected by the glaciation of the Pleistocene except for the highlands of Tasmania. The Alpine glaciers of Mount Kosciusko have left their record

of refrigeration, but there was no continental ice-sheet anywhere in Australia. This fact serves to bring out the relative intensity of the early glaciations compared with that of the Pleistocene in the Southern Hemisphere, and the contrast is independent of the factor of altitude, since there is no evidence that the Australian continent was notably higher within its present confines in Cambrian and Permian times than it is to-day. But while Australia was not glaciated in Pleistocene time it was affected indirectly by the development of continental ice-sheets in other parts of the world. These ice-sheets were so extensive and so thick that the abstraction of water from the ocean to form them lowered the surface of the sea and permitted the streams to cut valleys in the continental margins to lower levels than before or after glaciation. When the water was restored to the sea by the melting of the great ice-sheets the surface of the sea rose and invaded the valleys. Drowned valleys in the shape of splendid harbors are thus characteristic of the coast of Australia, particularly its east and southeast coast. But from the end of the Tertiary down to the present there has been in progress a slow elevatory movement of the eastern margin of the continent. The drowned valleys show that the rate of this uplift has been slower than the rate of down cutting of the valleys. But however slow it may have been, it is apparent that the strand of the sea, as restored by the melting of the last glaciers, would not reach so high on the coastal slope as did the earlier strand before the sea surface was lowered. That earlier strand would, therefore, be expected as a geomorphic feature of the coast above the present functional strand. Such elevated strands are a common feature of the east coast of Australia at about fifteen feet above sea-level, and their altitude may be taken as a measure of the amount of uplift to which the coast has been subjected in the

BROADSIDE VIEW OF THE DARLING FAULT SCARP

ON WHICH THE WESTERN MARGIN OF AUSTRALIA, NEAR PERTH, HAS BEEN DROPPED ABOUT 1,000 FEET. ON THE SURFACE OF THE DROPPED BLOCK DELTAIC ALLUVIATION HAS BUILT UP THE COASTAL PLAIN SEEN IN THE FOREGROUND

interval of the last lowering of the sea surface.

It has been suggested that, just as the Paleozoic sediments of the Appalachian trough were derived from the waste of the land mass of Appalachia, which has since for the most part sunk beneath the Atlantic, so the Paleozoic sediments of the East Australian trough were derived from a land mass to the east of the present continent, which has since almost entirely sunk below the Pacific. The Permian glaciation suggests the former existence of a large land mass in the Great Australian Bight. This fragmentation of the primitive Australian continent and the shrinkage of its area by the foundering of its periphery are further indicated by movements of later date. The Darling fault scarp of Western Australia, a post-Tertiary feature, is clearly due to the dropping away from the continental plateau of a coastal block, upon the depressed surface of which has been built up the present coastal plain by the extension of stream deltas and the counter extension of dunes from the shore. The Sterling Range fault, in the southwest corner of Western Australia, is an expression of the dislocation of that corner from the main plateau, with downthrow seaward to the southwest. The abrupt change of level, between the southern margin of the continental shelf and the sea-floor of the Great Bight, suggests a similar dropped block with no coastal plain, the fault lying far to seaward of the sea-cliffs. Since the southern margin of the continent is here veneered by marine Miocene beds the dislocation and dropping of the block must be post-Miocene. The rifting in the vicinity of Adelaide, which resulted in Spencer Gulf, Vincent Gulf and Torrens Lake, is a manifestation of continental fragmentation, part of which at least is post-Tertiary. The coastal region about Melbourne has been dropped relatively to the interior plateau in post-Tertiary time by the Bacchus Marsh fault. The post-Miocene separation of Tasmania by the depression of Bass strait appears to be another step in the fragmentation process. On the east side of the continent the post-Tertiary uplift of the plateau, which by dissection gave rise to the Eastern Cordillera, was accompanied by a relative depression of the coast. At the front of the Blue Mountains of New South Wales this was effected by a monoclinal fold. Farther south to the west of Lake George the same displacement found expression in a fault indicated by the Cullarin scarp. In Queensland great normal faults with downthrow seaward are prominent features of the geological structure of the coast for over two thousand miles. The Great Barrier Reef is regarded by Australian geologists as sessile upon a dropped block.

It is thus evident that the Australian continent on the west, south and east presents a foundering coast to the ocean. As there is reason to believe that the southern extension of the continent from which the Permian glaciers moved north over more than half of the continent has been engulfed, and that the land mass to the east, whence were derived the Paleozoic sediments, has been similarly engulfed, so we may see in the physiography and structure of the coastal region good reason to believe that the process of foundering and engulfment is still going on. It is thus fairly certain that Australia is to-day but a remnant of its former extent, and that with the persistence of the process of fragmentation it will in the future become still smaller. What engulfment of the fragments means is a geological mystery, but there is many a fact that stares us in the face of which the same may be said. It is safe to say, however, that the fragmentation of the continental margin is a process of adjustment to gravitative stresses due to progressive crustal instability. But this is merely

a restatement of the problem. The mystery remains.

The distribution of population and the nature of its industry in the continent thus geologically characterized are determined largely by its climate. The two chief factors in the climatic control of man's migrations and activities are the humidity and temperature of the air. A brief reference will therefore be made to these, as they vary over the surface of Australia.

The south central part of the continent, the area of which is not well determined but is between one quarter and one third of the whole surface, has a rainfall of less than ten inches. This arid country extends as a belt widening eastward from the shores of the Indian Ocean nearly to the longitude of Melbourne, and from the tropics to the shores of the Great Australian Bight. Concentric with the boundary of this central arid region is a belt, broad on the north and east but narrowing to nothing on the south, having a rainfall of between ten and twenty inches. This belt comprises about one third of the area of the continent. Outside of this is a much narrower belt, with a rainfall of twenty to thirty inches. The remainder of the continent, a little more than one tenth of its total area, adjacent to the coast, has a rainfall of over thirty inches.

The seasonal distribution of rains is important in its influence on agriculture. In the summer months from November to April inclusive, the rains come in the north and the south is dry; while in the winter the south receives its rain and the north is dry. But in the coastal regions of Eastern Australia the rain is fairly evenly distributed throughout the year. The rain which falls in the wheat-growing season, April to October, is particularly valuable. Half a million square miles of Australia receive a rainfall of ten inches or more during these months, and this is the limit of the wheat-growing area. If we assume that one quarter of this area, about 125,000 square miles, has a soil suitable for wheat, then at ten bushels per acre Australia could produce eight hundred million bushels of wheat. But fallowing and rotation of crops would reduce this to four million bushels annually. And the average yield would be still farther reduced by occasional crop failure due to drought. The recognition of the fact that wheat may be grown in regions of very scant rains if those rains come in the growing season has led to a great extension of this branch of agriculture in recent years, particularly in South Australia and Western Australia. The present production of wheat in Australia is about one hundred million bushels.

A rainfall of ten inches or more, without regard to the season of its fall, has generally been held to determine the area suitable for the pasturing of sheep. Thus in those regions where the rains fall from April to October the pastoral industry now meets the competition of agriculture for the utilization of the land. The shepherd generally yields to the farmer and is turning more and more to the interior desert for pasture for his increasing flocks. This larger utilization of the desert for pasturage has been made possible in recent years by the extensive development of artesian water in regions where there is no water at the surface, although there may be adequate vegetation to sustain flocks of sheep.

Two thirds of the area of Australia is in the south temperate zone and one third is in the tropics. For the two hottest months of January and February the mean temperature in the tropics is from eighty to eighty-five degrees, while in the temperate zone it is from sixty-five to seventy degrees. For the coldest month, July, the mean temperature in the tropics is less than seventy-five degrees, and in the temperate zone less

than fifty degrees. The summer heat in the temperate zone is dry, and, owing to the clear skies which prevail, radiation is active, so that the nights are agreeably cool. In the tropics the prevailing temperature is favorable to sugar-cane, cotton and rubber in regions where the rainfall is ample. Of these the cultivation of sugar-cane is an established industry, particularly in Queensland, where there are many sugar mills. On the plateau lands of the tropics, away from the coast, where the rainfall exceeds twenty inches, cattle do well and there are many herds; but the business of exporting beef is at present suffering from the competition of the Argentine.

These general physiographic and climatic features of Australia have determined the permanent concentration of its population in the more humid and cooler coastal regions, while the great interior of the continent remains an uninhabited desolate wilderness. As an illustration of how real a barrier the desert is to migration it may be of interest to note that while the English sparrow flourishes in Eastern Australia, it has never been able to make its way across central Australia to the west coast. A few years ago two sparrows were brought in a cage on a French ship to Fremantle, where they escaped. When this fact became known the entire population of Western Australia was seized with a panic; all the guns in the country were requisitioned and a great hunt was organized. It was only when the two poor sparrows were eventually shot dead and their carcasses properly identified by ornithological experts, that the people with a great journalistic sigh of relief resumed their normal occupations. After many years the rabbit succeeded in getting across the desert, and rabbit-tight fences were promptly built across the western side of the continent to hold him to the desert.

Man has been scarcely more successful than the sparrow, and the well-watered fertile soils of the west coast have been peopled not by overland migrations, as in the case of our middle west, but by ships as in the days when our goldseekers went around the Horn.

Like California Australia had its gold rush in the middle of the nineteenth century, and the temporary concentration of population thus occasioned was on the climatically agreeable eastern and southeastern side of the continent. The gold placers were found in regions where the older metamorphic and granitic rocks form the terrane; and they were reached from harbors where Brisbane, New Castle, Sydney, Melbourne and Adelaide have since established themselves as great metropolitan and industrial centers. The exploitation of the placers led to prospecting for the sources of the gold which enriched them, and so gold-bearing quartz reefs were discovered and mining camps were founded on both sides of the continent, which have become famous for their output of bullion. These were all located in the same terranes of ancient metamorphic and granitic rocks, and were all tributary to the growing cities of the coast, including Perth on the west. The successful exploitation of the gold mines led to the discovery of ore bodies in which copper, lead, zinc, silver, tin and iron were the chief metals, and these were extensively worked as gold-mining gradually declined. The discovery of telluride gold ores at Coolgardie and Kalgoorlie on the western margin of the great interior desert and the remarkable output of the older Mt. Morgan mine in Queensland led to a great revival of interest in gold-mining at the beginning of the present century. These great mines have been prolific of gold for several decades, but are now approaching exhaustion of profitable ore. The mines at Kalgoorlie have built a substantial city in the desert, but only at the expense of a thirty-inch steel pipe through which the water is lifted from the coast

and pumped by relay stations for 350 miles into the dry interior. When the mines are eventually exhausted and abandoned, the major use for the water will be on the fertile soils farther west, and the hitherto flourishing city of Kalgoorlie will become not less desolate than the buried cities of the deserts of Turkestan. But even if the mining of gold were now to wholly cease in Australia, the stoppage would not endanger the prosperity of the country. In the seventy or eighty years during which gold-mining has flourished it has not only served as a stimulus to the influx of a population possessed of great vigor, and has exercised a notable control in the distribution of that population, but it has contributed in large measure to the building up of the great cities of the coast, and has supplied and happily distributed the capital necessary for the establishment of more permanent pastoral and agricultural industries.

Australia is fortunate in having in the region of dense population a most agreeable climate, fine harbors and vast quantities of excellent coal. The best coal is found in various horizons of the Permian near the eastern coast, but coal of less importance is also found in Mesozoic and Tertiary formations. This coal and the existence of iron within convenient reach has led to the establishment of a great steel plant at New Castle, about one hundred miles north of Sydney, on the coast. No oil has yet been found in the rocks of Australia, but the day is rapidly approaching when it will be found profitable to extract from coal all the gasoline needed for her automobiles and other gas engines, and the failure to find oil will cease to be a cause of chagrin.

The most notable industry of Australia and her most important source of wealth is the growing of wool. The total number of sheep in Australia at the present time is reported to be about 106 million, or about twenty-four for every head of population. The flocks are limited in their distribution to regions where the annual rainfall is in excess of ten inches. Where that rainfall occurs in the winter months there is a steady tendency to use the land for wheat-growing and so restrict the pastoral area. But this is more than compensated by the gradual extension of the pastoral area in the dry interior of the continent, particularly where water is obtainable from artesian sources. The development of underground supplies of water in the dry eastern central part of the continent is a notable feature of the economic progress of the country. Here a great basin of undisturbed Mesozoic rocks extends from the Gulf of Carpentaria across Queensland into northern New South Wales and South Australia, occupying more than one quarter of the area of the continent. This basin receives the drainage of the western flank of the Eastern Cordillera of Queensland, and the lower formations of the basin are saturated with water which promptly rises to the surface when these formations are pierced by borings. The utilization of this supply has made possible the establishment of sheep stations with vast flocks in regions where there is no surface water, although there is sufficient vegetation to support sheep. The supply is very large and borings are being steadily extended, but it is of course limited by the replenishment from the drainage of the Eastern Cordillera. When the annual draft on the underground supply equals the annual replenishment the limit will have been reached. So far as I am aware little or none of this artesian water is used for irrigation in agriculture, doubtless due to the remoteness of markets and the lack of transportation facilities.

The steady growth of the pastoral industry from the beginning of the nineteenth century to the present and the remarkable improvement in the breeds of sheep and the quality of wool indicate

that the altitude, climate and vegetation of Australia are especially favorable to the life of the animal which has contributed so much to the prosperity of the country. There is every reason to believe that the production of high-grade wool will steadily increase for an indefinite time; and this permanence and stability of the pastoral industry of course implies a very thinly populated land, with few settlements that could be called villages, very meager transportation facilities and very few roads such as are common in a farming country. The interior region where sheep flourish is and will always remain a wilderness; and, although farmers in the agricultural districts nearer the coast have their flocks, the great bulk of the wool comes from the stations in the wilderness. These stations in the interior are immense holdings running into hundreds of thousands and even millions of acres for individual concerns, which are leased on a very small rental but which are subject to ultimate subdivision and sale if the land proves available for agriculture. When we add to the dry sheep country the vast territory which is so arid that it never can support flocks or herds the immensity of the wilderness relatively to the populated areas becomes most impressive.

Besides the production of wool the pastoral industry is the basis of a large export trade in mutton, beef and hides, which, however, owing to competition, is not at present so profitable as the wool trade.

In recent years Australia has made notable advances in horticulture and produces now not only an abundance of fruit for domestic consumption, but also some for export. The apples of Tasmania particularly are shipped in increasing quantities to Europe. The hardwoods of Western Australia have also become an article of commerce.

The principal exports of Australia arising from its productive industry are thus: wool, mutton, beef, hides, wheat, oils, specie, metals, fruit and hardwood. The principal imports are: clothing, manufactured metals, foods, Oregon pine, paper, drugs, alcoholic drinks, oils, leather, jewelry, earthenware and tobacco. In its past history Australia has imported most of the necessities and luxuries of civilized life and has met these imports by the export of a few staple commodities in world-wide demand. To-day there is a pronounced tendency toward becoming more self-sufficient. Manufactures in great variety are being developed in the centers of dense population. The new steel plant at New Castle has been mentioned. This will greatly minimize the imports of rails and structural steel and will supply steel for many manufactured articles that were formerly imported. The sugar mills of Queensland now supply sugar for the whole of the commonwealth. New woolen mills are meeting a part of the demand for woolen fabrics. Quarries, ceramic plants and cement mills are supplying the bulk of the building materials used. The native woods are coming into more general use. Machine shops, foundries and engineering works are common in the cities. The manufacture of vehicles, harness and saddlery dates from early days, but is now feeling the advent of the automobile. Of printing, engraving and the making of books there is no end. Furniture, bedding, upholstery, chemicals and drugs are produced in increasing quantities. The day is approaching when Australia will be relatively as self-sufficient from an economic point of view as the United States or Canada. Yet its deserts will always be inhospitable. Its physiography and climate determine that it will always be essentially a pastoral and agricultural country, that it will always export wool and wheat. As its manufacturing self-sufficiency in-

creases its imports will more and more take the form of luxuries rather than the necessities of life.

The insular character of Australia, the concentration of its people near the coast and their dependence on the sea for touch with the rest of the world, have determined that it shall be a maritime nation. Their travel has always been by sea and all their commerce has been sea-borne. Surrounded by the sea the Australians have a sense of unity and unchangeable completeness of domain which is not found in Europe or America. To them the sea is a kindly element which is part of their possessions. Throughout the nineteenth century before the confederation of the separate colonies into the commonwealth there was a well-established coastwise trade between the various coastal cities, besides the overseas commerce. The facility which the sea afforded for travel and for commerce between these now great cities has had an interesting influence on railway construction. When railways were first built in the middle of the nineteenth century little attention was paid to through traffic. The various colonies built their railways with little regard to what their neighbors were doing. The purpose of railway construction was to facilitate travel and the hauling of freight within the boundaries of each colony. Intercolonial travel and commerce by rail was not considered important because the ships took care of that, though it would be interesting to know what hand the shipping interests had in the matter. The indifference to through or intercolonial traffic is clearly shown by the fact that each colony determined upon, and maintains to this day, a railway gauge of its own. The gauge in Queensland is 3′ 6″, in New South Wales it is 4′ 8½″, in Victoria it is 5′ 3″ and in South Australia and Western Australia it is again 3′ 6″. The new transcontinental railway built by the commonwealth between Port Augusta and Kalgoorlie is the standard gauge 4′ 8½″. The latter was built for political reasons as a condition of Western Australia's coming into the Confederation. It has been running now for several years, but there is no economic or business reason for its existence. Nobody lives in south central Australia on the line of the railway except the people who run the railway. There is a small amount of transcontinental passenger traffic, most of it as part of the travel between England and the cities of eastern Australia; but there is no freight to carry. All freight goes by sea. Imagine a railway system in America trying to maintain itself without freight! And yet another transcontinental railway is now in process of construction from Port Augusta to Darwin, although there is no more hope of freight for the new line than for the existing one. As long as the people of Australia live along the coast so long will freight be shipped by sea from one part of the coast to another; and no railway dependent upon freight for its economic justification has a hope of survival.

THE NEBULAR HYPOTHESIS IN THE NINETEENTH CENTURY

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THERE is little doubt that the nebular hypothesis of Laplace exerted an important influence on the scientific thought of the nineteenth century, but the extent to which it was completely accepted by scientific men is often overstated. In a recent popular article by an eastern psychologist it is referred to as:

> that first theory of modern evolution propounded about 1800 by Pierre Simon La Place and called the nebular hypothesis, which is taught in all our high schools and colleges and accepted without murmur or dissent by many of our most devoted church members. It affirms that every physical object in the universe got here by the original motion of particles of matter, or star dust, infinitely small, scattered throughout space. By Newton's laws of motion the particles attracted each other, rushed together in space, formed rotating masses like our sun, which cooled and threw off smaller masses making planets, which in turn cooled, hardened, and formed among others our earth. . . . It showed how, without the intervention of mind, our material world is controlled and how it came into being.

In an article on paleontology by an eastern professor the following appears:

> For over a hundred years, the Nebular Hypothesis of the great French astronomer, La Place, was accepted by astronomers and geologists with practical unanimity, as explaining the origin and history of the solar system. Now that hypothesis has no standing with astronomers and among the geologists of England and America, the ancient hypothesis is completely abandoned, for it has been conclusively shown that La Place's conceptions are mechanically impossible.

In a modern very excellent text on astronomy the following statement concerning the nebular hypothesis is made:

> This theory for many years was generally accepted as giving a reasonable explanation of the mechanical development of our solar system, and, with certain modifications, is still accepted by some scientists.

Recently, a professor of astronomy in discussing the modern theories of the origin of the solar system with a group of scientific men remarked:

> Astronomers will never become as enthusiastic over another theory as they once were over the nebular hypothesis. They have learned a lesson.

Some of the statements quoted are distinctly in error, while others are merely slightly misleading. The name is "Laplace," not "La Place." It is certainly not taught in all our high schools and colleges. The devoted church members who accept the hypothesis without murmur or dissent are following neither Laplace himself nor modern astronomers. Laplace did not outline a plan for the development of the universe, but for only a part of the history of the solar system. It should never have been considered as "explaining" the solar system, since it was merely the guess of an eminent astronomer as to the general outline of the explanation. In sketching the standing of the nebular hypothesis in the nineteenth century, one might well start with Laplace himself.

The nebular hypothesis was presented as the concluding pages of a book of popular character, "Système du Monde." In this book he remarks "—for first causes, and the ultimate nature of things, will be forever unknown to us." He presents the hy-

pothesis "with the distrust which anything not a result of observation or of calculation ought to inspire"; and gives only a bare outline. He more than once passes from one step to the next with "One can guess," and near the end inserts, "if the conjectures which I venture to propose on the origin of the planetary system are correct." For the benefit of those not familiar with this famous speculation, it may be worth while to state that Laplace assumes the sun in rotation and surrounded by a fiery nebulous atmosphere, which extended beyond the outmost planet. He assumed that, as it condensed, the accelerated rotation caused rings to be left behind, which eventually collected into the planets; and, "One can guess furthermore that the satellites have been formed in a like manner by the atmosphere of the planets." We, in our turn, may guess that Laplace considered it an interesting speculation and worth while, but he wanted his readers to understand that the guesses, even of an expert, are in a very different class from the scientifically demonstrated facts presented elsewhere in his book.

Two of the world's leading astronomers in the period immediately following Laplace were Arago, in France, and Herschel, in England. Both wrote popular books on astronomy, Arago's four-volume work, "Astronomie Populaire," appearing after his death, which occurred in 1853, and Herschel's "Outlines of Astronomy," appearing about 1836. In Arago's work the hypotheses of Laplace are referred to, but not given. The earlier hypothesis of Buffon is outlined and discussed at length. In the tenth edition (1858) of Herschel's work, the "nebular hypothesis" is mentioned and a few speculations given, none distinctly from Laplace, nor is his name mentioned. Following the reference Herschel writes, "But to return from the regions of speculation to the description of facts." In Grant's history of astronomy, published in England in 1852, nearly a column is printed in the index under the heading "Laplace," but the nebular hypothesis does not appear, nor was any reference to it noticed in casually looking over the pages of material on that famous astronomer. Evidently the astronomers of this period were not greatly interested in the speculation.

Darwin's famous book appeared in 1859, and in works on astronomy appearing immediately after its publication we find evidence that the hypothesis of Laplace was being thoughtfully considered. Professor Loomis, of Yale, wrote in 1865: "The nebular hypothesis must therefore be regarded as possessing considerable probability, since it accounts for a large number of circumstances which had hitherto remained unexplained." In this period, when men of reputation were giving it almost unqualified endorsement, the details of the hypothesis were examined, and difficulties were brought to light which did not appear in the bare outline sketched by Laplace. In 1861 it was announced that there were serious difficulties in getting the periods of the hypothetical Laplacian rings to agree with the periods of the planets. Kirkwood, in 1867, thought the evidence gave "the theory of Laplace a very high degree of probability," but about two years later published a difficulty which he had discovered. Others were finding difficulties, but in 1877 Simon Newcomb wrote in his "Popular Astronomy," "These difficulties may not be insurmountable."

A somewhat more critical opinion is expressed in the well-known "History of Astronomy During the Nineteenth Century" by Clerke (published 1885, revised

1887). This opinion, ten years after Newcomb's, is: "It is, nevertheless, admittedly inadequate. Of much that exists it gives no account, or an erroneous one. It is certain that the march of events did not everywhere—it is doubtful whether it did anywhere—follow the exact path prescribed for it. Yet modern science attempts to supplement, but scarcely ventures to supersede it." Several of the more serious difficulties are discussed briefly. In Ball's "Story of the Heavens," a book of popular character published about the same time as Clerke's history, a modified version of the hypothesis is given, incorporating points from other writers than Laplace. In fact Laplace's name is not mentioned. Ball does not mention specific difficulties, but at the start warns his readers that "It is merely a conjecture," and after outlining his version adds, "Such a speculation may captivate the imagination, but it must be carefully distinguished from the truths of astronomy, properly so called." From these and other writings of the period, it seems that forty years ago those who had investigated the question at all were fully aware that the story as developed in the nebular hypothesis was quite unsatisfactory. A few interested persons had suggested modifications; but the theory involved too much speculation and imagination to receive much serious attention in scientific circles. Because it was the sort of thing to "captivate the imagination," it was presented in many popular books and elementary texts almost as a well-established truth.

The first serious work on the theory which has supplanted the nebular hypothesis was commenced by the geologist, Chamberlin, and the astronomer, Moulton, at the University of Chicago nearly thirty years ago. Instead of starting with a nebula or a star surrounded by a nebulous atmosphere, as in the earlier theories, they assume the sun existing in a state little different from its present condition. It is suggested that the material of which the planets are now composed was ejected by tidal and eruptive forces, when another star passed quite close to the sun. The authors have supported the hypothesis with considerable mathematical work, and Jeans and Jeffreys have also worked on the subject, suggesting modification of several details in the work of Chamberlin and Moulton.

As a typical modern opinion on the origin of the planets, we quote from a recent article by Professor Russell in the *Scientific American:*

> The only available explanation of their existence appears to be the one now familiar—that the planets were ejected from the sun during huge eruptions caused by the close approach of a passing star, and set moving laterally in orbits by the attraction of the star as it receded . . . in the chaotic turmoil which must have followed the great outburst, detailed calculations become impossible, and we have to accept it simply as a fact that eight large masses and vast numbers of small ones remained in motion about the sun.

To sum up: the conclusions after an examination of popular works by leading astronomers of different periods are—that Laplace himself did not take the hypothesis as seriously as writers on popular science of twenty-five to fifty years ago. The astronomers following Laplace were not greatly interested before the publication of Darwin's book. In fact, the theory is not given in the three books examined which appeared just before that work. Immediately after the appearance of this epoch-making work on evolution, Laplace's hypothesis was quite popular, but as a consequence various persons attempted to fill in details omitted by the author, and difficulties were found. At first, naturally, it was generally believed that,

in spite of various difficulties, the general outline suggested by Laplace might be approximately correct; but in less than thirty years the recognized difficulties were such that a scholarly investigator questioned whether any of the details could be correct. Evolution was, however, a popular subject; the prestige of Laplace was great; and nothing worth while had been suggested to supersede the nebular hypothesis; so popular writers and elementary texts continued to present it until the general acceptance of the more modern theory was recognized.

In conclusion, we may remind readers that speculations on the origin of the solar system, like those about life on other planets, are discussed much more in popular than in scientific circles. Astronomers in general will readily concede the scientific value of Laplace's theory and of the work of Chamberlin and Moulton; but most believe that the average worker should restrict his research rather closely to facts of observation and calculation.

HEREDITARY CONSTITUTION AND X-RAYS

By Dr. ROBERT T. HANCE

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Is it conceivable that a future Solomon may be able to depend upon a technique for determining parentage that would be more reliable than maternal emotions? It is an interesting thought to play with, although not one for which this article is going to do much by way of prophecy. From the standpoint of the race, the specific parentage of children, beyond the eugenic aspects, is not a particularly important one and, if we are to draw any conclusions from the signs of the times, it is very apt to become less so in the future. Certain criteria are already proving occasionally useful in deciding who the parents of a particular baby may be when the mother becomes suspicious that the youngster delivered to her from the hospital nursery lacks the family "it." The determination of the type of blood (the blood groups) possessed by mother, father and child is satisfactory and entirely conclusive in certain cases but useless in others. The laws of heredity can also be depended upon to produce from blonde parents only blonde offspring, but these same laws will show how two brunette parents may also have blonde offspring. In the former case the birth of a brunette child would be quite adequate proof of a companionate alliance of some sort, while in the latter the legal value of the evidence would be nil, since it might very well be, and probably is, merely a case of so-called Mendelian segregation. Here, though the parents themselves were brunettes they carried the possibility of producing blonde offspring and when the right combination of germ cells occurred the blonde characteristics appeared.

The preceding paragraph perhaps intrigues the reader's interest to a point to which the following exposition of experimental results will prove but an anti-climax. We can not report as yet any conclusions that may apply to the various practical problems which we should so much like solved, but it is entertaining at times to get away from the rigidly defined restriction of scientific procedure and to allow our imaginations full swing. And who knows how hopelessly shortsighted and unimaginative our wildest stretches are going to appear when viewed from the future? Jules Verne in the days of his vogue was considered a delightful romancer. To-day there is little of interest in his stories as all his brain children have been supplanted by eugenic babies that far exceed in fact Verne's strangest imaginary production.

Beginning with the rediscovery of Mendel's work in 1900 a great many studies have been made that have resulted in a rather satisfactory demonstration of the laws that govern the transmission of parental characteristics to succeeding generations. We know, for instance, of the conditions of dominance and recessiveness which involve the appearance or submergence of certain traits. If a mouse whose ancestors are known to be pure bred for colored hair and which is therefore, for this character, itself pure or homozygous, to use the genetic term for this condition, is mated with a pure-bred albino mouse, the offspring will all have colored hair. As is of course very well known to-day, though these first generation hybrids are indistinguishable from the pure

bred colored parent, they produce when bred together black and albino offspring in the ratio of three to one. The first generation hybrids must obviously have carried the albino possibility in a submerged or recessive state. If we use the usual symbols, the hereditary constitution of these animals, as far as the hair color is concerned, will be more obvious. Let us have capital "C" represent the dominant colored-haired mouse and small "c" stand for the recessive albino. Since both animals had two parents, each of which contributed an hereditary determiner for color, the pure-bred colored mouse's formula should be "CC" while the albino will be "cc." In the formation of the germ cells these hereditary determiners separate so that each mature reproductive cell contains but a single determiner for each trait of the body. Considering hair-color alone, each "colored" germ cell would carry a single "C" and each "white" cell a single "c." It may be diagramed as follows:

	Dominant colored	(crossed with)	*Recessive white*
	CC		cc
Germ cells	c		c
First generation		Cc	all colored mice

When two of these first generation animals are crossed, this is the result.

	Cc	(crossed with)	Cc
Germ cells	C		C
	c		c

Second generation—	CC	pure or homozygous colored
All possible combinations of germ cells	Cc Cc	hybrid or heterozygous colored
	cc	pure or homozygous white

From this it can be seen that the recessive character can only appear when it is present in a pure condition or, in other words, when it has been carried by each of the two germ cells that united to form the new animal. On the other hand, it has always been impossible to determine except by breeding tests whether a colored mouse is pure or hybrid for pigmented hair. In the case of a mouse homozygous for colored hair this color has been produced by a double dose of the hereditary determiner for this character, one having come from each parent. The hybrids, however, that are visibly indistinguishable from the others have but one determiner back of their hair color.

Now there has been no evidence that the extra color determiner in the pure bred mice represents or produces anything physiologically different from that found in the hybrid. It has always seemed reasonable, however, that a character supported by two hereditary determiners might be "stronger" than one dependent for its expression on a single determiner. As the result of some recent work we now have evidence of the correctness of this belief.

During these studies on the biological effects of X-rays it was found that, following certain conditions of raying, the pigmented hair of mice is shed and is eventually replaced by hair that is white. The question was raised as to whether there might be any difference in the reaction to X-rays of mice homozygous or heterozygous for hair pigmentation. This was an obviously important point, although at first the possibility of conclusive results with the available methods did not seem great.

The plan of attack involved a general exposure of a number of homozygous and heterozygous colored mice at what had been determined to be a reactive age, from ten to fourteen days. The exposure used was the smallest dose that was known to cause the falling out of hair on the general supposition that if there was a physiological difference between pigmentation that had resulted from either one or two genes a small

dose might serve to change the weaker without affecting the stronger genetic character.

The expectations were entirely realized with certain important and unanticipated additions. The regrown hair on the rayed backs of heterozygous colored mice came in a mixture of pure white and pure colored hairs in ratio of approximately from three to five white to one colored. The general color effect of the mixed hairs was light gray. There was some tendency for the general color effect to become lighter as the animal became older. I am not certain whether this is due to whitened hairs becoming still more white or to colored hairs dropping out.

A few of the hairs on the backs of the homozygous colored mice also came in white, but the majority of the hairs were noticeably darker than normal.

These results have been constant and without a single exception in six litters of homozygous colored mice (fourteen animals) and four litters of heterozygous colored mice (thirteen animals).

The above data seem to prove beyond question that a dominant coat color character that has been produced by a single determiner (in other words is heterozygous) is not as "physiologically strong" as the same color resulting from two determiners (homozygous).

When all is said and done what we are really striving for is more knowledge of the chemistry of living processes in order that we may the better be able to control them. The biologist is trying by every possible means to learn more of these complicated phenomena and it is usually easier to understand the normal through observations of the abnormal. Hence he is continually trying to upset the usual activities by throwing experimental monkey wrenches in the guise of ultra-violet rays, X-rays, chemicals and a variety of other things into the living works to see what happens. The effect of X-rays is attracting most attention at present, and their value in demonstrating a very nice difference (doubtless chemical) between two characters of different hereditary constitution is obvious in the cases just described. This is the first instance where an hereditary difference between two animals has been shown by other than natural breeding methods and it opens a very interesting field for experimentation and speculation.

From the genetic point of view the results of these experiments suggest the possibility of getting at the chemical basis of hereditary and biological phenomena. Any conclusions reached along these lines might very probably have a bearing on the therapeutic aspects of X-radiation. X-ray therapy has some virtues and many faults. Greater knowledge of all phases of the biological action of X-rays may enable us to control or to duplicate in some simpler way the valuable effects and to largely, if not completely, eliminate the less desirable.

But imagination and prophecy aside for the present, we have actually worked out in the described experiment only one thing which may be briefly told as follows. Hair color that is produced by two hereditary determiners has proved more resistant to X-rays than the same character resulting from but one determiner and the only apparent explanation of these reactions is that the former is literally stronger than the latter and consequently required more radiation to kill it. This suggestion gains support from the fact that more severe exposures to X-rays will produce similar results in the homozygous or pure-bred colored mice, while the difference between the pure-bred and hybrid animals appears only when minimum doses are used.

PARASITES OF BLACK BASS

By Professor RALPH V. BANGHAM

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AMONG the various factors which limit the growth and reproduction of fish, parasitism plays an important part. There are many causes of the limitation of the numbers of bass in our lakes and streams but only the damage due to parasitism and disease will be considered in this article. It is difficult to estimate the degree of damage due to parasites and disease on adult bass. The host fish is seldom killed. Bass are not often subject to any epidemic type of disease which kills large numbers at one time. Under the unnatural and crowded hatchery conditions certain parasites are sometimes brought in which spread rapidly, causing death of large numbers of bass.

Almost all species of fish carry parasites, and the black bass is no exception. At all ages, from the fry to the adult stage, a bass usually harbors several species of parasites. Young fish are especially susceptible to parasitic attacks. If they do survive their growth is retarded and these fish fall prey to carnivorous fish for a longer period than if their growth proceeded at a normal rate.

Often, in older bass, damage done by parasites is first noticeable in loss of sexual powers. The adult bass are obtained as breeders for the hatcheries from Lake Erie. A large number of these fish are found to be entirely or partially sterile due to the infestation of the gonads with a species of larval tapeworm. Several other states which formerly obtained breeders from Lake Erie have discontinued this practice because of this infestation.

The gills and fins are often attacked with minute flukes which do considerable damage. At times the intestine is so completely filled with masses of tapeworms or round worms that there seems to be but little room for food. As many as fifty larval tapeworms have been taken from the intestine of a young bass less than two inches in length.

Parasitism sometimes occurs in the flesh of the fish, and these so-called "grubby fish" are usually discarded by fishermen, although no harmful effect would result if the fish were eaten.

The parasites of bass belong to several different classes: (1) Plant parasites, fungi and bacteria; (2) one-celled parasites or protozoa; (3) flukes; (4) tapeworms; (5) nematodes or round worms; (6) acanthocephala or thorn-headed worms; (7) fish lice; (8) leeches.

In the first group Saprolegnia or water mold causes damage, especially in the spring. As previously mentioned, many of the adult bass which are used as breeders in the hatcheries are obtained by trap nets from Lake Erie and transported to the hatcheries in tanks by auto trucks. Even with careful handling many are bruised and are attacked by Saprolegnia. There is often serious loss among such fish. This fungus attacks the eggs at certain times, especially those laid by bass of low vitality or eggs laid late in the season.

There are but few bacterial diseases of bass and these are of limited distribution.

The protozoan parasites seldom infest bass under natural conditions. Nearly all these which affect bass are external parasites and are found under hatchery conditions. One of these, the "itch" or "white spot" disease, spreads very rap-

idly and is often the cause of a heavy mortality among young bass. The disease appears as small white pimples about the size of a pin head projecting over the body of the fish. Affected bass are at first very active but soon refuse food, become listless and come to the surface apparently gasping for air.

Another protozoan forms larger white cysts in the gills of the young bass and if sufficiently numerous seriously impairs the respiration of the fish.

One other small one-celled parasite attacks the skin, especially in the region of the fins. A silvery, glossy scum forms over the body and the fish becomes very sluggish. Often portions of the skin fall off before death.

The bass are fairly resistant to certain chemicals, such as weak solutions of alum, copper sulphate, acetic acid, and most of these diseases can be held in check by treatment if the infestation is recognized in time and proper care used in handling the fish. It is much more important in these protozoan infestations as with other parasites to attempt to prevent the disease gaining a foothold than to treat it afterward.

Several species of flukes infest bass. Two species are external parasites, two are found in the skin and flesh and many are internal; these latter being found chiefly in the stomach and intestine.

The internal flukes are probably the least harmful of the bass parasites, but those which are external often do considerable damage to the gills, skin and fins of the host—especially where they are found in ponds where many bass are confined.

Of these flukes one very small species attacks the skin and the fins, causing large raw patches usually near the base of the fins. The losses of young fish in hatchery ponds are often high when this form is present. These parasites are transmitted from one fish to another by contact, and the entire life cycle may be passed on a single fish. Methods of treatment have been developed which are fairly successful in the control of this disease.

A very closely related species of fluke attacks the gills of large-mouth bass. Small numbers of this minute fluke are nearly always found on the gills, but occasionally the numbers are increased so as to cause serious impairment of the respiration. At one Ohio hatchery last year the large-mouth bass breeders became seriously affected. These fish were removed from the pond and treated with a .2 per cent. solution of glacial acetic acid. The treatment was not entirely successful, as the flukes were often deeply embedded between the gill filaments and the solution failed to reach them.

A larval fluke which is the cause of the "grubby bass" is found in the flesh as small round yellow cysts. Often there are hundreds of these larval forms in the flesh of a bass. The liver is also frequently riddled with watery cysts of this species. Two areas where bass were very heavily infested have been found—one in Lost Creek near Troy, Ohio, and the other in streams flowing into Lake Erie from northeastern Ohio. The degree of infestation is higher in late summer. The adult of this parasite is found in the esophagus of certain fish-eating birds. The first larval host is unknown, the bass probably being the host of the second larval stage.

Another smaller larval fluke is often found encysted beneath the skin, causing black pinhead-like spots in the bass of warm lakes and streams. These are seldom found in bass of Lake Erie.

The tapeworms are of the greatest importance as bass parasites. There are six species of these found in Ohio bass, and an individual fish usually harbors

but one or at most two species at a time. Proteocephalus amblopIitis, the tapeworm of Lake Erie bass, is the largest and does by far the greatest harm to the host of any of this group. It is the only one of the tapeworms of the bass which has two stages of its life history in the fish. In the larval stage it forms cysts in the liver, mesenteries and reproductive organs. This is the form already referred to as the one causing sterilization of many adult bass. The adult stage is found in the intestine of the bass. The distribution of this form is limited in Ohio to bass of Lake Erie and smaller lakes. It has not been found in stream bass, except near where a lake empties into a stream.

This form has little if any free existence. The egg when it reaches the water must be eaten by the proper species of water flea if it is to develop. When taken by the proper host the larva of the tapeworm burrows through the intestine and continues larval development in the body cavity. If this infested form is eaten by a young bass or certain other species of fish, the host is digested, but the parasite passes through the wall of the intestine and migrates to the liver, spleen and reproductive organs, where a second larval stage is passed. Here the worm leads a more or less inactive life and can not reach maturity unless this young fish is eaten by an older bass. If this occurs the larval tapeworm develops to maturity in the intestine of the bass.

The other species of tapeworms do not seem to cause very grave damage to the host. One form is found in young bass from Lake Erie during their first year. These small tapeworms are obtained by the bass soon after they begin taking food. They are acquired by eating minute water fleas carrying the larval stage of this form. In this form the development proceeds in the intestine of the bass without a second larval stage.

Another form which is intermediate in size between the two above mentioned is Proteocephalus fluviatilis and has been found to infest 90 per cent. of the bass from streams. It is also found only as an adult in the bass. Often from ten to twelve individuals of this species are found in the intestine of a single adult bass.

The nematodes or round worms prove a serious pest to certain species of fish, but very few are found in lake bass. In certain streams of southwestern Ohio a large species of nematode is quite common in bass and may do some damage to the host.

The Acanthocephala or thorn-headed worms live in the intestine of the bass with their long spiny heads embedded in the wall. There are often hundreds in one fish, and the tears made by their hooks may cause severe injury to the host. These are the most common and widely distributed of the bass parasites. Small-mouth bass are usually more heavily infested with these thorn-headed worms than large-mouth bass.

The fish lice are blood-sucking forms usually attached inside the mouth or on the gills. If numerous they cause death of the bass, but only in a few cases are such large numbers found. They are more numerous in warm lakes than on stream bass.

Leeches are the largest of the external parasites and if many of these worms are found they very greatly weaken the host. They very rarely attack the bass in large numbers.

In most cases bass from Lake Erie and smaller lakes showed a higher degree of infestation than those from streams. This finding agrees with that of Essex and Hunter, who reported in 1916 the results of a study of parasites of fish in

the upper Mississippi and Missouri river basin.

The distribution of the parasites in Ohio is especially interesting in light of the fact that adult bass from Lake Erie have been placed by the Fish and Game Division in inland lakes and streams annually since 1883. If the proper intermediate hosts were present the Lake Erie parasites should be widely distributed in Ohio lakes and streams. Yet several parasites are peculiar to Lake Erie bass, such as the small species of tapeworm and several of the internal flukes. The large tapeworm of Lake Erie bass has established itself in certain inland lakes and even in some hatchery ponds, but it has only been found a few times in about one hundred and fifty examinations of stream bass. Where found it was from bass taken near lakes where the lake bass carried this form. It will be hardly possible to control parasitism of fish in natural waters, but it is important to determine the life history of many forms. In many cases it is very difficult to determine with any degree of certainty the harm parasites do to fish. There is need for more light on this problem.

Results can and are being obtained in the control and prevention of parasitism in the fish hatcheries. Some things which can be done are: (1) Obtain healthy breeders; (2) avoid overcrowding and its consequent weakening of fish; (3) give fish sufficient food and thereby develop enough vitality in the fish to resist better parasitic attacks; (4) prevent access of young fish to any chance infestation from adult fish; (5) study the life cycles of the fish parasites with a view to eliminating the intermediate hosts if possible; (6) develop new methods for treatment of parasitic attacks.

THE MOST VALUABLE TREE IN THE WORLD

By Lieutenant Commander P. J. SEARLES

NAVY YARD, BOSTON, MASS.

If one hundred Americans were asked "What is the most valuable tree in the world?" there would probably be a dozen or more different answers. But those who had lived in the tropics would be unanimous in replying, "the coconut tree." The coconut is perhaps the most desirable tree in existence as it provides food, drink, shelter and profit to millions; it can be made to serve innumerable necessary purposes; and without it the future of tropical lands would be dark indeed.

There is no necessity of describing the appearance of the coconut tree, as every one is familiar with at least the pictures of it. Every book with scenes cast in warm climes, steamship advertisements, Army and Navy recruiting posters, all use the coconut as pictorial propaganda. But, even though acquainted with its appearance, one can only learn by investigation and contact with the industry the multitude of uses to which the tree, its fruit and its leaves can be put. Let us consider somewhat in detail the value of the tree and how tropical people live by it.

The trunk of the coconut tree yields a timber (known in European commerce as porcupine wood) used for buildings, furniture, firewood, curios, etc. It is a light, spongy wood of low strength, which has found a wide use because of its prevalence. Houses built of this wood are not very lasting, but repairs cost only the labor, as the trees grow everywhere. Extensive use is made of the leaves for thatching roofs and sides of buildings; when well done, a good water-tight job results. The leaves are also woven into many kinds of baskets, cajan fans and other commodities and in some communities are even used as clothing after suitable preparation. Rafts and foot-bridges are among the uses to which the wood is put.

As food and drink the coconut is especially valuable. One's mind immediately considers the meat of the nut itself, but this is only part of the story. The meat is used somewhat, but to a lesser extent than commonly believed. It is usually eaten just as removed from the shell, although it may be kept for a considerable time and consumed in a rather sour, fermented state; or it may be prepared and put up in the grated form sold in groceries throughout the world. The meat is best when young and soft, in which condition it is frequently scooped out and eaten with a spoon. Not only is the meat an enjoyable human food, but chickens and hogs thrive on it. The young bud cut from the top of a tree gives one of the most delicious salads that can be found anywhere. It is a crisp substance like celery, but less stringy, and, of course, with an entirely different and indescribable flavor. It is variously known as "palm salad," "palm cabbage," or "palmetto."

The milk of the nut has a sweet, fresh taste, and is refreshing when drunk from an almost ripe nut on a hot tropical day. It may be taken at nut temperature or iced, plain or mixed with other juices, and is frequently used for a most enjoyable ice cream.

The juice of the tree, however, is much more widely used than the milk of the nut, and is a veritable treasure house. This juice is obtained from cuts

in the unopened infloresecence at the top of the tree, which may also (as in Ceylon and India) be bruised and pounded to accelerate the production. The resulting juice or sap is pathologically similar to the fluid produced by a sore on the human skin. The sap begins to flow in four or five days after the cut is made, and drips into vessels tied underneath the cut. In some parts of the world earthenware jars are used, although joints of bamboo are the most common. If the juice is to be used for alcoholic drinks, it is considered best to employ an old tube which contains the necessary ferments. It is a common sight to see an entire grove of trees connected by bamboo, somewhat like gutters on the roof of a building, all emptying into one or more huge jars. Each time a tree is visited an exceedingly thin slice is taken from the cut, using knives made especially for this purpose. In some localities the juice of red pepper is put on the cut daily to prevent insect attacks. From one to four quarts of the sap can be secured daily from a normal tree, the flow continuing for several weeks.

Fermentation of the sap starts as soon as it leaves the tree, and how far it is allowed to proceed depends upon the use to which it is to be put. The fresh sap, commonly known as "toddy" or "tuba," contains about five or six per cent. alcohol. It must be consumed at once unless, of course, a higher alcoholic content is desired. As ferment rapidly appears in the collecting vessels, it is necessary (in order continually to secure sweet toddy) to change the vessels daily, always using new and clean ones. In many parts of Polynesia, Malay, Java, Sumatra, etc., considerable sugar for home consumption is made from the toddy by putting into it a small quantity of some finely powdered bark which is rich in tannin. This crude sugar is occasionally refined into clean white sugar suitable for export; such a process is not commonly found, however, except in Java.

The most famous drink in the Orient for centuries is made by distilling the toddy. The resulting liquor is known as "arrack" by sailormen and "vino" by the Spanish; in a few localities it is called "aguardiente." It is a powerful drink, with, at times, over 50 per cent. alcoholic content, and is rather disturbing, temporarily and perhaps permanently, to the user. In many places in the Orient and the South Seas its manufacture is forbidden, but the process is so simple and speedy that it can not be stopped altogether, no matter how rigid the authorities. It is an aphorism of the tropics that prohibition is impossible in the vicinity of the coconut tree.

William Dampier, the old pirate (incidentally he was one of the crew of the ship which rescued Robinson Crusoe from his lonely island), knew of toddy and arrack as evidenced by an extract from his journal:

> Beside the Liquor or Water in the Fruit, there is also a sort of Wine drawn from the Tree called Toddy, which looks like Whey. It is sweet and very pleasant, but it is to be drunk within 24 hours after it is drawn, for afterwards it grows sowre. Those that have a great many Trees, draw a Spirit from the Sowre Wine called Arack. Arack is distill'd also from Rice and other things in the East-Indies; but none is so much esteemed for making Punch as this sort, made of Toddy or the sap of the Coconut Tree, for it makes most delicious Punch; but it must have a dash of Brandy to hearten it, because this Arack is not strong enough to make good Punch of it self. This sort of Liquor is chiefly used about Goa; and therefore it has the Name of Goa Arack. The way of drawing the Toddy from the Tree, is by cutting the top of a Branch that would bear Nuts; but before it has any Fruit; and from thence the Liquor which was to Feed its Fruit, distills into the Hole of a Callabash that is hung upon it.
>
> This Branch continues running almost as long as the Fruit would have been growing, and then

YOUNG COCONUT TREES

A FEW TREES GROWING WILD

TREES ALONG DUNCAS BEACH, GUAM

A LARGE COCONUT PLANTATION NUMBERING ABOUT 20,000 TREES

FREE-GROWN, NUT-BEARING TREES

it dries, away. The Tree hath usually 3 fruitful Branches, which if they be all tapp'd thus, then the Tree bears no fruit that year; but if one of the two only be tapp'd, the other will bear Fruit all the while. The Liquor which is thus drawn is emptied out of the Callabash, duly Morning and Evening, so long as it continues running, and is sold every Morning and Evening in most Towns in the East-Indies, and great gains is produced from it even this way; but those that distil it and make Arack, reap the greatest profit.

The above extract is from an account of the Island of Guam. This island, now a possession of the United States, is prohibition dry, but from the numerous arrests for violation of the eighteenth amendment it is evident that the coconut tree has not yet learned to obey the law.

Two other by-products of the sap are quite common, yeast and vinegar. In many communities no other yeast is ever used, even by transient white residents. In the making of vinegar special care must be taken to prevent putrefaction of the sap, either by the use of a bark rich in tannin, or by coating the containers with lime.

In a commercial sense copra is the most important product of the coconut tree. By copra is meant the dried meat of the nut. Usually the first step in copra making is the removal of the husk of the nut. In many Pacific islands the whole nut is split with a machete, although in a few places splitting machines are used. The milk must be thoroughly drained from the nut. The meat is rasped out in various ways; in the Philippines there is commonly used a "Kabyawan." This is a convex iron burr mounted on the end of an axis around which a cord is wound several times and run down at each end to a pedal. The burr bears teeth over its entire surface. The operator works the pedals with his feet, whirling the burr; the burr is pointed away from the operator, so that when he takes a half nut in his hand and draws it against the burr he can watch the removal of the meat.

THATCHING A ROOF, AGANA, GUAM

A SCHOOLHOUSE IN TALOFOTO, ISLAND OF GUAM, OF BAMBOO FRAMING AND COCONUT THATCHING

COCONUT TREES GROWING WILD ALONG THE OCEAN SHORE AND THE PAGO RIVER, GUAM

In many places the removal is done by a hand knife.

Immature nuts should not be used in copra making; the chief loss is not so much because poor copra (or less copra) is obtained, as because poor copra mixed with good copra lowers the market value of the latter. Copra from certain localities only commands half the price in world markets as copra from other places because of such mixture. Nuts cut from trees increase in yield of copra if allowed to stand in piles some weeks before being opened. Nuts that fall naturally from the trees are used at once.

There are several methods of drying the copra to remove the undesired moisture. Sun-drying requires from four to seven days of bright weather and produces high grade copra if not rained on. The best copra is produced by uninterrupted drying from the time the nuts are opened until desiccation is complete. It is important that copra should become surface-dried as soon as possible. This is done by opening the nuts in the morning, drying all day and sheltering at night. The sheltering is done in Guam by covering with mats woven of coconut leaves.

In some places the sun is relied on for preliminary drying up to the time of removal from shell, when subsequent drying is performed on grills or in kilns. In Tahiti, where the whole nuts are split, strips are then partially torn from the husk and by means of these the nuts are hung in the sun. In a few days the meat falls from the shells, and is then given a little additional drying. In most other lands (Cochin, for instance) the copra is laid on clean mats to dry.

Copra is also dried over free fires, thus receiving not only heat, but smoke and soot as well. The husks and shells of the nuts are frequently used as fuel, the entire process, of course, varying with local conditions and customs. The most uniformly good copra is made in drying-houses heated by steam or hot water; this method is followed particu-

CHAMORROS OF THE MARIANA MAKING A MEAL OF COCONUTS

larly in Trinidad, Ceylon, and some parts of the Philippines. In the old German lands of New Guinea and the Bismarck Archipelago kiln-drying is common.

Most copra is shipped after drying to the United States and France, although there are a few oil-extracting plants in Ceylon, India, Mariana Islands, etc. In the factories the copra is thoroughly macerated by grating or scraping and grinding, and the oil is extracted by hydraulic presses or electrically-driven rolls. About twenty-five gallons of oil can be obtained from one thousand nuts. The oil is a white, semi-solid substance at ordinary temperatures, with a rather disagreeable odor (from the volatile fatty acids) and a mild taste. Under pressure it separates into a liquid and a solid portion, the latter, known as coco-stearin, being used in making candles.

What are the copra and oil good for? First consider the copra after the oil has been extracted. It is commonly known as copra meal, and is used widely as food for cattle and poultry. It is also of value for use in cakes and candies.

COCONUT TREES ARE EVERYWHERE IN THE TROPICS

SECTION OF A COCONUT PLANTATION

Sometimes it is made into a broth and soup for human consumption.

The oil is of more extensive utility and is a valuable article of commerce. It is used in the manufacture of marine soap, which forms a lather with salt water; every ship afloat carries a supply of this soap. The various grades of oil (which depend upon the maturity of the nut and the care in drying) are used for candles, high-grade soaps, cold creams, face lotions, shaving creams and other toilet preparations. The oil has both cleansing and lather-making properties. In the tropics especially the oil is used for dressing the hair; unperfumed this does not always lead to pleasantly odorous results, as a rancid smell soon develops. Oil obtained after fermentation has set in is used for candles and cheaper soaps. From the oil can be made an excellent waterproof polish for furniture, automobiles and other articles. Immense quantities of glycerine are obtained from the oil, this being a particularly important industry during the World War. Numerous butter and lard substitutes are obtained, some being advertised as coconut products. In England especially the oil is also used in the making of powdered milk. All these industries are of considerable importance, and all depend largely upon the coconut.

Another valuable and widely used product of the coconut tree is "coir." Coir is the commercial name of fiber prepared from the husk of the nut. It is used extensively for cordage, especially in the Philippines, and the Mariana and Caroline Islands. Among its many purposes are rope, fish nets, fiber for tying together parts of houses (which is desirable on bamboo and thatched huts in districts where earthquakes are frequent), caulking boats, etc. It is especially good as a caulking material, for it swells in water and makes a tight seam.

Coir rope is quite elastic, stretching 25 per cent. without breaking. It is durable, does not decay easily, but wears out rather rapidly because of the brittleness of the strands. It is very little used as textile fiber because of harshness, coarseness and brittleness, although

NOTE THE WAY IN WHICH COCONUT TREES ALONG THE SHORE ALWAYS GROW TOWARD THE WATER

clothing of coir can be found in many of the less civilized sections of the Orient and the South Seas. It is valuable for door mats, brushes of all kinds, stuffing for mattresses and other purposes.

The Laccadive and Maldive Islands furnish most of the European coir, although some is obtained from Ceylon and Cochin. Cochin-coir is the trade name for coir of finest quality. In making, the husks are macerated by soaking in water until the fibers can easily be freed from the waste matter in which they are imbedded. The fibers are then combed several times, washed, dried in the sun, combed again and sorted into the various qualities.

The shells and waste matter of the coconut are good for fuel, the former having a rather extensive use as charcoal. The shells are also valuable for fertilizer because of their potash content.

A few minor uses of the coconut tree remain to be noted. In many tropical countries spiral grooves are cut along the trunk of the tree and water is caught in a rain by flowing from the fronds along the grooves into a receptacle. The shells are widely used for water vessels, drinking cups, carved ornaments, ash trays, toys, curios, etc. In England, even, there is a rather popular county fair amusement, "throwing at the coconut." At times, also, a crude sail cloth made from the nut fibers is found on native boats in isolated places. In Saipan, one of the Japanese islands of the Pacific, coconut meat is used as a bait to lure deep-sea fish into surface nets.

What other tree can offer the varied uses of the coconut? Food, drink, shelter, clothing, toys for the savage child, curios for the tourist, illumination for the native hut, cosmetics for milady's boudoir, refreshing drink or hard liquor, rope or soap—all come from the coconut, the most widespread and most valuable tree on the face of the earth.

THE PROGRESS OF SCIENCE

THE EDGAR FAHS SMITH MEMORIAL COLLECTION

THE priceless collection of chemical memorabilia assembled by the late Dr. Edgar Fahs Smith, who was internationally known as a chemist and was provost of the University of Pennsylvania for ten years, has been presented to the university by his widow, Mrs. Margie A. Smith, and will be preserved intact in its present setting in the Harrison Chemical Laboratory, it was announced at the university recently.

With the acquisition of the collection, which will be known as "The Edgar Fahs Smith Memorial Collection in Historical Chemistry," the university is making special arrangements to safeguard it, following which it will continue to be accessible to visitors and students of the history of chemistry, many of whom, during Dr. Smith's lifetime, had frequent recourse to it for study and research work.

Eventually, it is expected, the university will create a fund, the interest of which will be devoted to the perpetual maintenance of the collection, and additions will be made to the collection from time to time, if possible, so that it may be an ever-growing asset to the chemical department of the university.

Dr. Smith, who died on May 3 this year, had served as emeritus professor of chemistry at the university after resigning the provostship in 1920. He was a former president of the American Chemical Society and of the American Philosophical Society, had served as a member of the United States Assay Commission; as trustee of the Carnegie Foundation, and as technical adviser to the Disarmament Conference, and was the author of more than 200 scientific papers as well as numerous books on chemistry. In 1926 he was awarded the Priestley medal bestowed by the American Chemical Society for outstanding achievement in the science of chemistry, and he also was the recipient of the Elliot Cresson medal from the Franklin Institute "for distinguished contributions to electrochemistry," and the Chandler medal from Columbia University for contributions to historical chemistry. In addition, France made him an Officer of the Legion of Honor "for distinguished services to chemistry." An appreciation of Dr. Smith, together with a portrait bearing his signature, were included in THE SCIENTIFIC MONTHLY for July.

Dr. Smith became interested in the history of chemistry early in his career and his private collection of chemical memorabilia, which is said by many authorities to be the best of its kind, was compiled during years spent in patient search in all parts of the world for rare items in which he was interested.

The collection, as presented to the university, comprises three main divisions. The first contains about 500 autographed letters and manuscripts of eminent chemists of all nationalities; the second is made up of approximately 1,000 portrait prints and engravings of prominent chemists from the days of the alchemists to the present, and the third consists of nearly 1,000 books on alchemy and chemistry.

In addition, there are a number of chemical preparations and a variety of chemical apparatus which Dr. Smith had accumulated during his career as teacher and research worker, and an unusually rare collection of books and manuscripts relating to the history of the University of Pennsylvania and the lives of outstanding alumni and members of the faculty.

THE EDGAR FAHS SMITH COLLECTION

Of Dr. Smith's collection of books on alchemy and chemistry the majority are in their original bindings and many are printed in Latin, German and old French.

The oldest book included is Geber's "Alchemy," which was printed in Nuremburg in 1545, while probably one of the rarest in the collection is the "Theatrum Chemicum Britannicum," printed in London "at the Angel in Cornhill" in 1652. This work was edited by Elias Ashmole and contains a series of old English poems on alchemy, one of which is by Geoffrey Chaucer.

Letters from eminent chemists of all nations from the earliest times down to those of Pasteur and Madame Curie are among the autographed manuscripts found in the collection. Notable among these is one addressed by Joseph Priestley in 1792 to a member of the National Assembly of France.

In this letter, Priestley accepts the honor which they do to him by making him "a citizen of France," but declines "nomination to the approaching National Convention."

Dr. Smith had long been interested in the life and works of Priestley and in 1926 had deposited in the Priestley Museum, at Northumberland, Pa., a collection of Priestleyana which was said to be the largest of its kind and which included Priestley's balance and the original manuscript of "Priestley's Memoirs."

Many of these items, as well as those in his collection of chemical memorabilia were presented to Dr. Smith by friends all over the world who were familiar with his zeal for collecting historical

IN HISTORICAL CHEMISTRY

material, but the majority were found by Dr. Smith personally.

When the Harrison Chemical Laboratory was erected at the university in 1894, Dr. Smith selected two rooms in the laboratory for his offices and these rooms he continued to occupy until his death, making them the depository for his collections. As his collections increased, these two rooms gradually began to assume the appearance of a chemical museum, and as news of the variety and rarity of Dr. Smith's collections became known among chemists and others, the rooms became the mecca for students of the history of chemistry from all over the world.

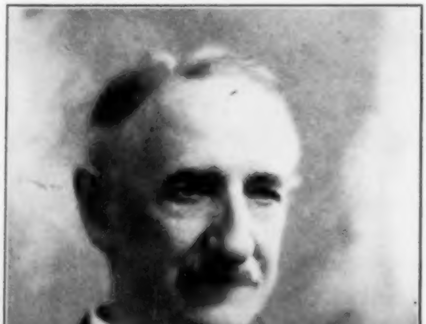
So important did his treasure house loom in the eyes of chemists that when the American Chemical Society met in Philadelphia in 1926, an exhibition of historical chemistry was held in Dr. Smith's office and hundreds of chemists, including Professor Bertrand, head of the Pasteur Institute in Paris; Dr. Ernst Cohen, of Utrecht, Holland; Prince Conti, of Italy, and Professor Sapojnikoff, of Leningrad, Russia, were in attendance.

According to University of Pennsylvania authorities, a number of letters expressing the hope that Dr. Smith's collections would be preserved intact in their present setting and made accessible to interested students of chemistry have been received since Dr. Smith's death from men prominent in chemical circles. As a result, following Mrs. Smith's generosity in presenting the collection to the university, the work of fireproofing and otherwise safeguarding the rooms in the Harrison Laboratory which contain the collections is being carried on as rapidly as possible so that the collection may again be made available to those interested in research in the field of chemical history.

THE AWARD OF THE BENJAMIN G. LAMME MEDAL

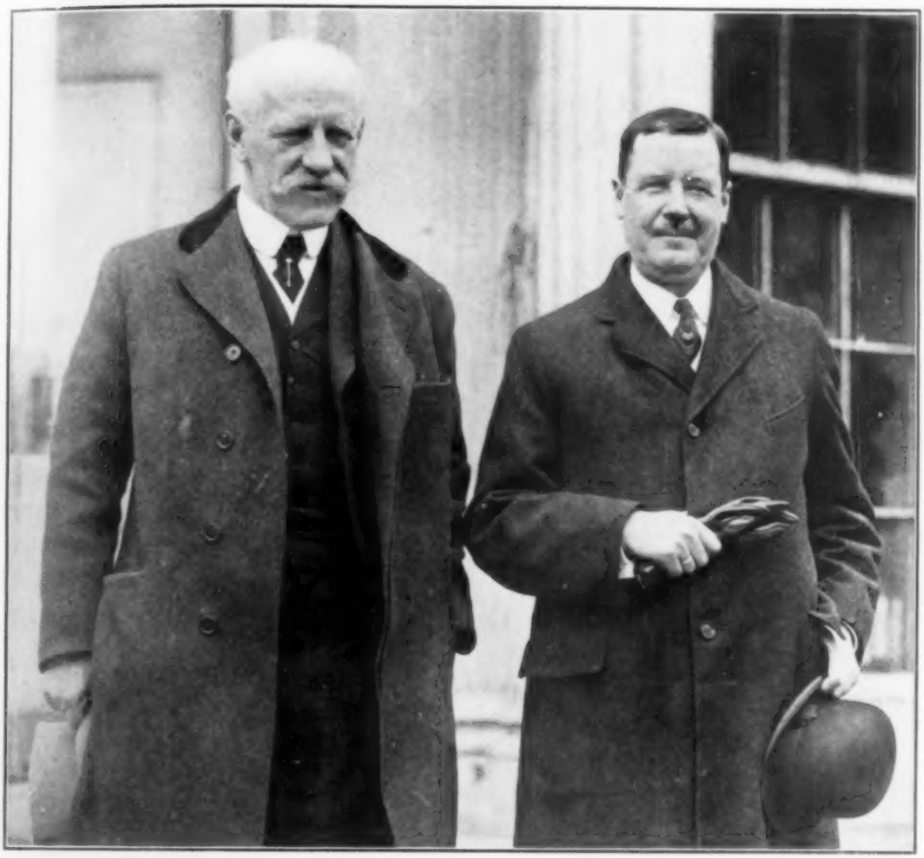
THE first award of the Benjamin G. Lamme gold medal "for accomplishment in technical teaching or actual advancement of the art of technical training" has been made to Dr. George Fillmore Swain, of Harvard.

Dr. Swain has attained distinction as a thorough and practical engineer, an inspiring teacher and an authoritative writer. He received his technical education at the Massachusetts Institute of Technology and the Royal Polytechnic School of Berlin. Honorary degrees have been granted to him by New York University and the University of California.


PROFESSOR SWAIN

In 1887 Dr. Swain began his teaching work at the Massachusetts Institute of Technology. Since 1909 he has been a distinguished member of the faculty of the Harvard Engineering School. Dr. Swain has served as a consulting engineer for the Massachusetts Railroad Commission and has been associated with a number of engineering enterprises mainly in the field of transportation. His achievements have stood the test of time and his published works provide a means for extending his influence to the future.

The medal which has been awarded by the Society for the Promotion of Engineering Education was provided by the will of the late Benjamin G. Lamme, formerly chief engineer for the Westinghouse Electric and Manufacturing Company. It was Mr. Lamme's desire to advance the engineering profession by encouraging good technical teaching.



DR. FRIDTJOF NANSEN

WITH THE HON. H. H. BRYN, FORMER MINISTER FROM NORWAY TO THE UNITED STATES.

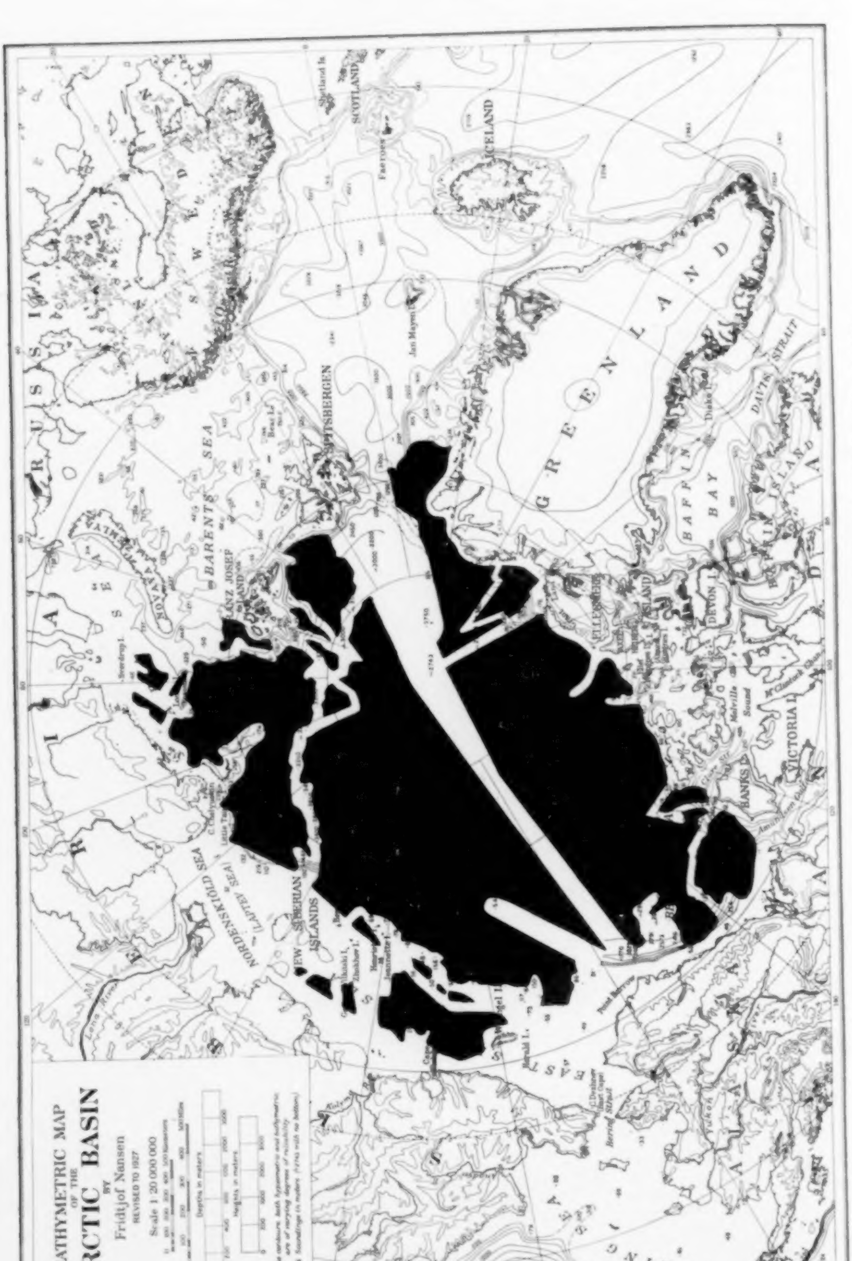
THE INTERNATIONAL SOCIETY FOR THE EXPLORATION OF THE ARCTIC REGIONS BY MEANS OF THE AIRSHIP

By I. P. Tolmachoff

Carnegie Museum, Pittsburgh, Pa.

The importance of aeronautics during the world war resulted in developments which have been found to be of great value in peace time. Flying machines heavier and lighter than air have already become regular instruments of transportation, especially in Europe. The wider application of flying apparatus to scientific and technical work is only a question of time. Even before the war the Russian government, in 1914, supplied its Arctic relief expedition with an aeroplane. During the war, aeroplanes were widely and successfully used as topographic surveying instruments. In different countries aeroplanes are now used in the fight against such agricultural pests as mice and injurious insects.

The national air connections soon were followed by the international ones. Not speaking of regular connection by air between different countries of Europe, the organization of regular air



DR. NANSEN'S BATHYMETRIC MAP OF THE ARCTIC BASIN

communication between the countries of the Old and New World is a task now confronting scientists and engineers. In spite of a number of disasters, the Atlantic Ocean has already been spanned with air routes. The Pacific, too, will soon be conquered. An examination of different possible air routes between Atlantic countries and those of the northern part of the Pacific showed that the shortest way leads through the Arctic. This route would run over the North Pole, or at least very close to the pole, over mostly unknown Arctic Ocean. The accompanying map shows very clearly these unknown regions, which, although they have never been explored by man, make about two thirds of the whole area of the Arctic Ocean. Not long ago this unexplored territory was even larger. It has been reduced to its present size through information obtained on recent flights to the North Pole, which, although undertaken without any special scientific purpose, have resulted in the discovery that a great strip of the Arctic is nothing but water surface. To make future flights over the pole safer, it is certainly necessary to explore these unknown areas, and this is one of the most important tasks of the new International Society. On the same map the route of a future expedition of the society is marked with a dotted line.

Germany took the initiative, but the enterprise finally resulted in the foundation of "the International Society for the Exploration of the Arctic Regions by means of the Airship," or, in abbreviated form, of the "Aeroarctic."

The official birthday of the society is October 7, 1924, although the preliminary work was carried on during several preceding years. Dr. Fridtjof Nansen, Arctic explorer, scientist and professor at the University of Oslo, internationally known as a political and social worker, was elected president of the society. His participation was a guarantee for the purely scientific purposes of the new society, and it soon secured a wide international recognition.

The central seat of the organization is Berlin. The society was received enthusiastically, and in a short time numbered two hundred members, elected among Arctic explorers and those connected with aeronautics or interested in the investigation of Arctic regions. The following countries are represented in the society: Austria, Bulgaria, Czechoslovakia, Denmark, England, Esthonia, Finland, France, Germany, Holland, Italy, Japan, Latvia, Norway, Poland, Spain, Sweden, Switzerland, The United States of America, and The Union of Socialistic Soviet Republics. In this list there are absent: Belgium, Canada, Greece, Hungary, Ireland and Portugal, but the three first-named countries have already been involved in the organization of local groups and perhaps should be included in the list. The present number of members is probably not less than three hundred, for it is daily increasing.

According to the statutes of the society, members belonging to a particular country, provided they are represented in sufficient numbers, may organize a local national group or branch. Such a group has just been organized in the United States. The officers of the American branch are: President: Dr. L. A. Bauer; vice-president: Dr. J. A. Fleming, of the Carnegie Institution in Washington; secretary: I. P. Tolmachoff, of the Carnegie Museum of Pittsburgh.

The financial means of the society consist of membership fees (at the present time an individual fee is $1.00 a year, that of an organization $5.00), donations made by friends of the society and appropriations by the governments. The last amount has been fixed accord-

ing to the population of the respective countries. Countries having a population below two millions pay \$10.00 a year; two to ten millions, \$50.00; ten to fifty millions, \$150.00; above fifty millions, \$300.00. According to this schedule the share of the United States is \$300.00 a year.

Although still in the period of organization, the society has already begun its scientific activity. Its first and well-attended international meeting was held in Berlin, November 9–13, 1926. The next international meeting is planned for the approaching summer and will be held in Leningrad.

The society is already preparing an expedition to the Arctic in 1929. To own an airship and to supply it with the necessary material would certainly be impossible for any private society, even with greater financial means than the one in question. The German government, however, is apparently ready to devote one of its airships to this purpose. The Russian government has also promised to erect a mooring mast on Murman from which point the expedition will start its polar flight. The use of an expensive airship, and not of comparatively cheap aeroplanes, is dictated by the character of the proposed enterprise, which must be a scientific expedition aiming at various investigations, and abundantly supplied with all necessary apparatus, as well as having a large staff of scientists. The great number of these is demanded by the conditions of work. Passing over the Arctic would take only a few days, but the scientific work of the expedition will need to be carried on daily during the whole twenty-four hours, which is possible owing to the permanent day of the Arctic summer. This necessitates a triple number of scientists distributed in three daily shifts.

Besides this expedition the society is planning the permanent observation of the Arctic by means of a number of wireless stations which will encircle the Arctic Ocean, and which in their work will be closely connected with each other and the whole meteorological service of the northern hemisphere. The work of these land stations has to be supplemented by observations on the ice of the Arctic Ocean, made from temporary stations well supplied with a reliable staff, all necessary installations, provisions, etc. As means of transportation, flying apparatus will be used. This would also be able to bring relief to parties in case of trouble, which could be easily reported through the wireless.

In the month of April, 1928, the society began the publication of the quarterly magazine, *Arktis*, at the Justus Pertes publishing company at Gotha, Germany. Papers for the magazine may be written in English, French or German. The first number, for example, included two English and one French paper along with German articles. The international character of the journal is also shown by the distribution of its permanent contributors. According to a list published by the society, three of them are from the United States, two from Norway, two from Germany and one from each of the following countries: Austria, England, France, Holland, Russia, Sweden and Switzerland.

A new map of the Arctic regions, which will be published in many languages and which will be adapted to educational purposes, is being prepared.

Another task of the society is to work out and to perfect the technique of Arctic exploration, especially the construction of light wireless stations which could be easily adapted to transportation in flying machines. The fact that among collective members of the society there are such firms as Siemens & Halske and Siemens-Schuchertwerke shows that the new organization is well supplied with the technical forces, laboratories, instruments and financial means necessary for the purpose.